Member A.B.C.—A.B.P.

JULY 1939 • THE *Petroleum* **Engineer** • VOLUME X NUMBER 11

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A MAGAZINE OF METHODS FOR OPERATING MEN

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CIRCULATION—C. R. BARRETT, *Circulation Manager*

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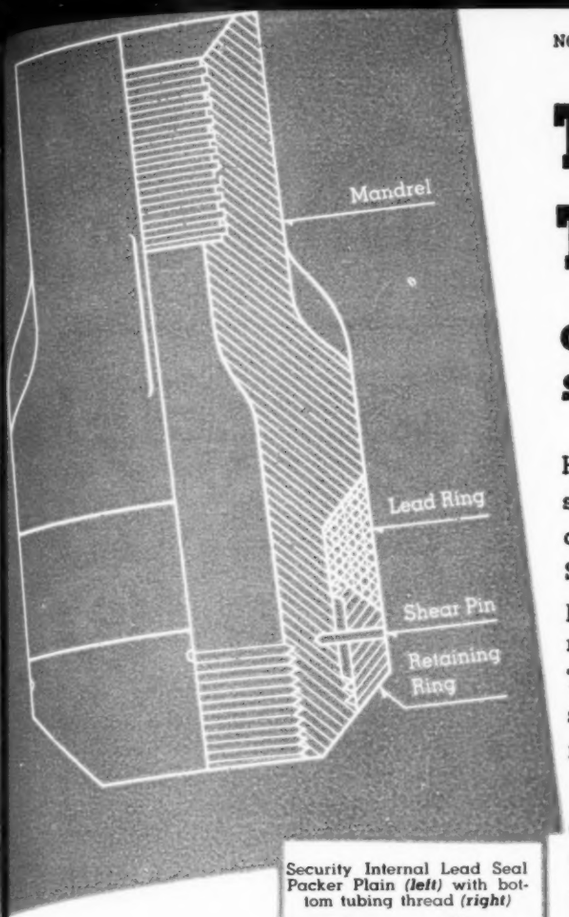

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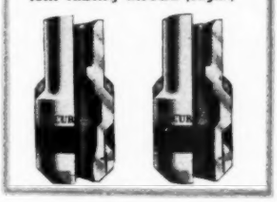

Security Internal Lead Seal Packer Plain *(left)* with bottom tubing thread *(right)*

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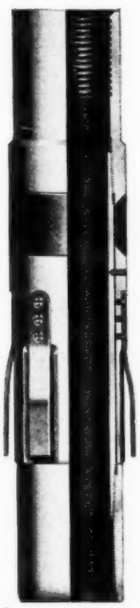
Security Drillable Slip Type Liner Hanger with Lead Seal Packing



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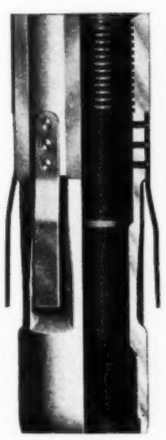

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The Course of Oil

By K. C. SCLATER

Salvaging the East Texas Field Lack of a well-spacing program and its enforcement, as has been stated in these columns at various times, has been at the root of the trouble in the East Texas field. While it is conceded that the greater the number of wells the larger the recovery, this in itself is no justification for close spacing.

Sound Practices Recognized by Court It would seem that acreage must inevitably be considered in allocating allowable production. It is this very fact that is causing concern because of its possible far-reaching effect—at least, so far as it applies to Texas, and in particular to the East Texas field. It may mean that the well with a twenty-acre spacing will be allowed to produce twice that of a well with a ten-acre spacing, or four times that of a well with a five-acre spacing.

Consider Ultimate Results Inclusion of acreage for determining well allowables in the East Texas field was suggested in a recent court ruling. A group of operators in that field has shown violent opposition to consideration of acreage in any form with the plea that it will work a hardship on many of the small operators. It is hard to reconcile the viewpoints of opponents to the court's suggestion on the grounds that it will be a hardship on the small operators.

Dissension Over Acreage Factor The acreage factor is the subject of wide dissension and one over which a bitter fight soon may ensue. The State Railroad Commission has not yet seen fit to include acreage in any form in its proration orders for the East Texas field. Yet it would seem that only in this way (i.e., by the consideration of acreage) can be avoided an irrational program of dense drilling that will be an ultimate detriment to the field—a consequence that the regulatory body surely cannot fail to foresee.

Unless some means of checking too dense a drilling program for the field is applied, well allowables must be reduced eventually to the point that an increase in allowable will become imperative.

Water Production Losses The production of water is accelerating the decline of reservoir pressure at an alarming rate. Should the present trend in the rate of water withdrawal be allowed to continue, the indications are that early 1940 will witness the end of the flowing life of the field.

Were no water to be produced with the oil from now on it is estimated that by January, 1946, at least two and one-half billion barrels of oil would be produced by natural flow.

Maintaining Reservoir Pressure With more than 23,000 wells in the field and continued drilling, it is inevitable that the allowable per well must be reduced still more. Increase of the field allowable is unlikely, and would be very unwise, for there is ample justification for holding it to what it is at present.

Excessive Drilling and Economics When production is prorated on a potential basis without regard to the acreage drained, a premium is placed on new drilling, which if persisted in, will result in allowables being reduced to the point that the production of oil becomes unprofitable. By allowing such a point to be reached the stability of production is threatened; a howl goes up for increased allowable, which, if not granted, will breed trouble.

East Texas Pressure Decline A further reduction in field allowable means that the well allowable would fall below that of marginal wells, in which case, it is quite likely the action of the Railroad Commission would be challenged. Court action probably would follow, for the legality of such a reduction in well allowable is a question that the courts in all likelihood would be called upon to decide.

The Shut-Down Fallacy A reduction in well allowables to below that of the marginal allowance would, it is feared, draw protests and the possibility of court injunctions on the part of a few operators.

Maximum Field Allowables Experience shows that the greater the number of wells in a field the harder it is to enforce proration. A good example of this is the East Texas field. Despite the benefits obtained from proration in that field, there has never been a time in its history when some operator was not clamoring for higher allowables.

Inequitable Proration Challenged It looks at the moment as though a change in the methods of allocating allowable production in the East Texas field were in the offing. It is likely, too, the change, if made, will involve acreage, consideration of which the Railroad Commission has heretofore avoided.

The foregoing comments are excerpts from *The Course of Oil* as far back as June, 1933, and as recent as June, 1939. During this period of harping, the soundness and wisdom of considering acreage in allocating production in the East Texas field have become increasingly apparent—will anything be done about it?

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« « HIGHLIGHTS IN OILDOM » »

California Oil Control Bill Passes

Designed to prevent waste, both on the surface and underground, the Atkinson bill has been passed by the California legislature and signed by Governor Olson. The terms of the act consider non-wasteful oil as that quantity reasonably marketable.

The three-man commission created to administer the terms of the new law has the following functions: (1) collection of data; (2) powers of investigation and inspection; (3) power to examine all properties, leases, books, and records; (4) power to test and gauge all oil and gas wells, tanks, plants, refineries, transportation facilities, and equipment; (5) the holding of hearings with power of subpoena; (6) establishment of methods of record keeping and reporting; (7) limiting and proration of production of crude oil and gas; (8) authority over refinery products when manufactured from crude beyond legal production limits; (9) issuance of certificates of clearance or tenders on transportation of products; (10) fixing of the drilling units (well-spacing); (11) power of confiscation of "hot oil", and (12) allocation of field and well allowables.

The act further provides that U. S. Bureau of Mines data on the industry are to be accepted as prima facie evidence on market demand, although the commission also has power to make its own investigations; places a limit on the spacing of wells to a maximum of one to 40 acres, and prohibits proration based on cubical content of pools.

●

Texas Commission Denied Stay of Ruling

The United States Fifth Circuit Court of Appeals, in session at New Orleans, Louisiana, has denied the Texas Railroad Commission's request for a stay of judgment in the lower court that enjoined the commission from enforcing its oil proration order in East Texas pending appeal of the case. The case in question is that of the Railroad Commission versus Rowan and Nichols Oil Company, appealed from the Western Texas District Court, which enjoined enforcement of the proration order and, according to the Railroad Commission's motion, permitted doubling of the oil output allowed under the commission's order in the East Texas field. The motion declared that judgment should be stayed because "great inequity, uncertainty, and confusion in the East Texas field will be prevented thereby."

The statement of the commission further pointed out that a stay of judgment, in event the order were finally invalidated, would provide a reasonable time in which to formulate and promulgate an order that would comply with the law as finally interpreted by the appellate courts.

The lower court's decision, given June 14, 1939, prevented the Railroad Commission and the attorney general from putting into effect a restriction of the Rowan and Nichols' wells to a daily allowable of 2.32 percent of the hourly potential. The commission claimed that the court, by its decision, increased the daily production from 112 bbl. to 220 bbl. and that the effect of the decision would be to destroy the status quo of the East Texas situation.

Judge Rufus E. Foster of the Circuit Court, although denying the Railroad Commission's motion for a stay, did, however, transfer the case from Fort Worth, Texas, to Atlanta, Georgia, and set the hearing date for October 2, in order to assure an early hearing of the case.

Oil Discovery Reported Near Liverpool, England

The discovery of oil at Formby, England, about nine miles north of Liverpool, has been reported by the Anglo-Iranian Oil Company, which has been drilling in that area for several months, according to a report from Consul C. J. Pisar, made public by the U. S. Department of Commerce.

Based on results already obtained, officials of the company express the belief that the oil deposits in the Formby district may eventually prove of commercial importance.

It is planned to continue the exploration work at Formby but it is recognized that considerable time must elapse before the commercial significance of the discovery can be determined, the report said.

●

Bill Would Regulate Illinois Drilling

A bill designed to regulate the methods of drilling oil and gas wells in Illinois is before the legislative body of that state and already has passed the house. The measure requires operators to file with the state department of mines and minerals a statement and map of each well to be drilled. Methods to be employed in filling dry and abandoned wells are prescribed, and it is required that notice of intention to plug and abandon a well be given to the state department, which shall supervise the work.

●

Connally Law Extended For Three Years

A bill extending the Connally "hot oil" law for a period of three years, after being passed by both branches of the legislature, has been signed by President Roosevelt. Secretary Ickes, who administers the law, said he anticipates no change in policy under the new extension and added that he favored "permanent enactment of the law as soon as possible as a step toward the protection of the needs for oil for the national defense and for the general welfare."

●

Albania's Petroleum Production is Expanding

Development of Albania's petroleum resources under Italian auspices is steadily progressing, according to a report from Consul General W. H. Sholes, Milan, made public by the U. S. Department of Commerce.

The exploitation rights are controlled by the Acienda Italiana Petroli Albania, the "AIPA", which in 1925 received a 50-year concession from the Albanian government. The company has drilled 380 producing wells at a depth of from 1200 to 2500 ft.

Drilling operations by the "AIPA" have resulted in an annual production from Albanian wells of more than 200,000 tons (1,352,000 bbl.).

During the first two months of this year, Albanian crude exports increased to 25,000 tons (169,000 bbl.), an indication that 1939 production will be considerably higher than in 1938 and preceding years. Although an eventual output of 300,000 tons (2,028,400 bbl.) or more a year is anticipated, such additional volume will doubtless involve further heavy capital investments in Albania on the part of the Italian company, the report states.

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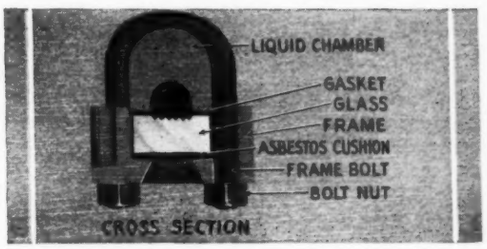

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Activities in Refining

Percent Refining Capacity Operated

Western Division, 62.6 Percent **Central Division, 84.2 Percent** **Eastern Division, 89.5 Percent**

THE Sinclair Prairie Oil Company has begun the modernization of its refinery at Sand Springs, Oklahoma. Work will be done principally during shut-down periods, E. B. Killick, refinery superintendent, announces.

●

Mid-Continent Petroleum Corporation has signed a license agreement with Gasoline Products Company, Inc., to cover its cracking operations, it has been announced. Mid-Continent operates several cracking units in its West Tulsa refinery. In connection with the patent license agreement, a survey is being made of the existing equipment by engineers of The W. M. Kellogg Company in coöperation with Gasoline Products Company, directed at improving the operations in general and increasing the octane number on the cracked gasoline. Substantial improvement in the operations are expected to be effected.

●

The refinery-gasoline plant division of Frick-Reid Supply Corporation has completed the installation of a 1200-bbl. per day Dubbs cracking unit in the refinery of the Midwest Refinery Company, Alma, Michigan.

●

The Arkansas Fuel Oil Company is constructing a natural gasoline plant in the Shreveport field, Louisiana. Capacity of the plant will be 25,000,000 cu. ft. of gas per day. Completion is expected the latter part of August.

●

The plant of the Pana Refining Company, one mile south of Pana, Illinois, will be completed in about 30 days, it has been announced. Officials of the company are Chase Savage, president; George H. Pfau, vice-president and general manager, and H. C. Goettig, auditor.

●

The Ben Franklin Refining Company, affiliate of the Bell Oil and Gas Company, is installing at its Ardmore, Oklahoma, refinery a 2-cycle Dubbs unit. Two cracking furnaces will be erected, having a capacity of 2000 bbl. per day. In addition, there will be a complete absorption and pressure-stabilizing unit, as well as Dubbs polymer equipment to process polymerized gasoline.

The refinery-gasoline plant division of Frick-Reid Supply Corporation is constructing a vapor-recovery and stabilizing unit for a Houdry installation at the Augusta, Kansas, refinery of the Socony-Vacuum Oil Company.

●

The refinery-gasoline plant division of Frick-Reid Supply Corporation has completed a new gasoline plant in the Luby field of Nueces county, southwest Texas, for the Stanolind Oil and Gas Company of Tulsa, Oklahoma. It will process 9,000,000 ft. of gas per day and recover 30,000 gal. of gasoline per day.

●

Fletcher Oil Company, Inc., Los Angeles, California, is constructing a single-coil Dubbs cracking unit and a non-selective U.O.P. catalytic polymerization unit near Wilmington, California.

The cracking unit has a rated capacity of 1100 bbl. per day of gas oil or 1700 bbl. per day of fuel oil. The polymerization unit has a rated capacity of 500,000 cu. ft. of gas per day. Both units are designed to allow for future increase in capacity.

The company is taking extensive precautions to prevent corrosion. Chrome-molybdenum tubes are used in the heater and the principal piping and valves. The reaction chamber and flash chamber will be lined with corrosion-resisting alloy, as will the lower section of the fractionating column.

The hot-oil pump will have a chrome-alloy metal block and stainless steel plungers.

The Fluor Corporation, Ltd., is the contractor. Universal Oil Products Company designed the unit and provided the specifications. Fluor supplied the drawings and is responsible for the construction.

D. S. Fletcher is president of the company, F. O. Fletcher, secretary, and A. R. Hudgins, treasurer.

The Fletcher company already has a skimming plant at Los Angeles.

●

R. G. Matthews, formerly secretary-treasurer of the Centralia Refining Company, and L. R. Flori, president of the Flori Pipe Line Company, are erecting a 3000-bbl. capacity refinery at St. Louis, Missouri. Crude supply will be from Illinois fields.

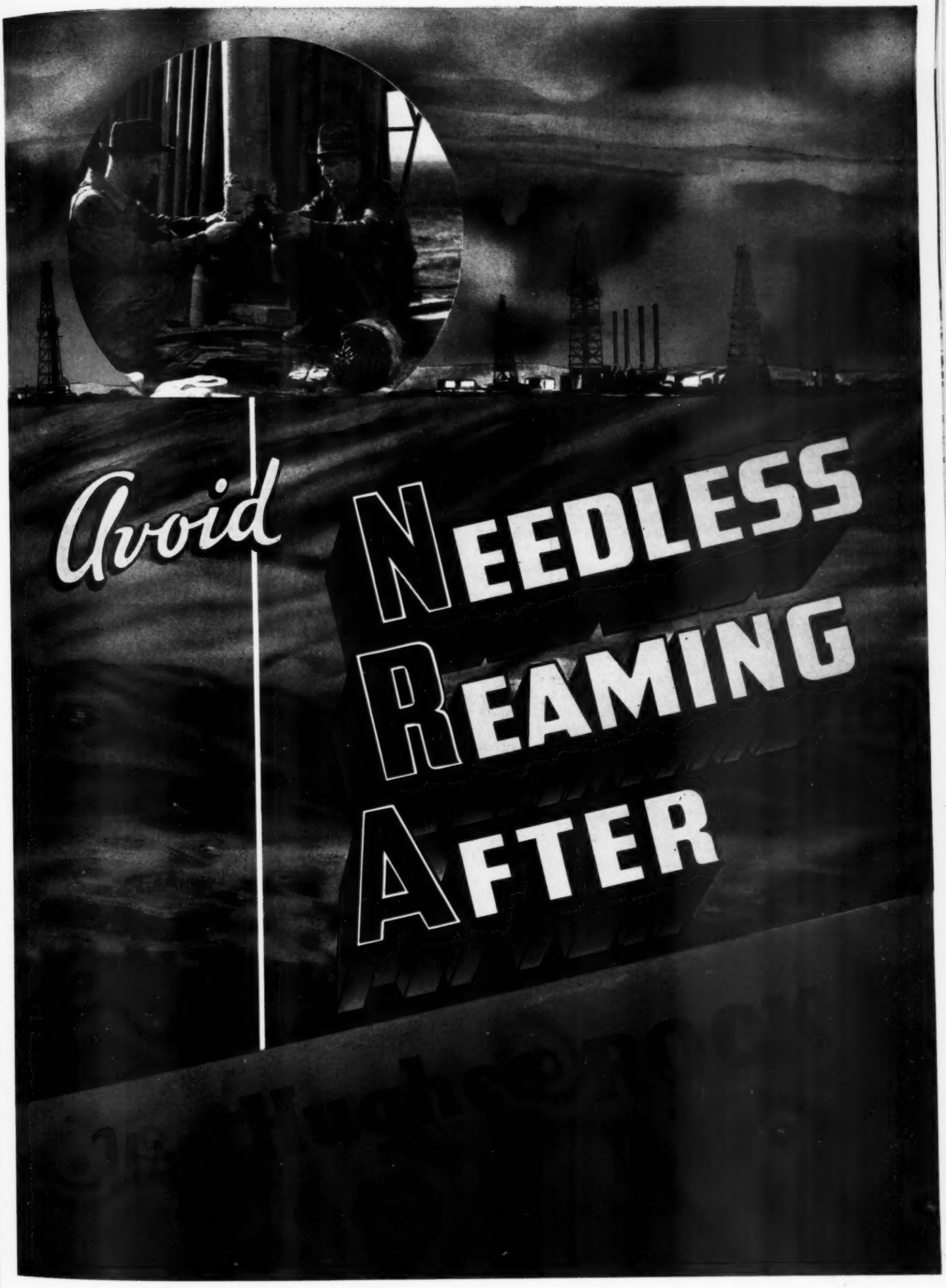
Crude Runs to Stills, Gasoline, Gas and Fuel Oil Stocks
Week Ended July 1, 1939

A.P.I. Figures

(Figures in thousands of bbl. of 42 gal. each)

DISTRICT	Percent Potential Capacity Reporting	Daily Average Crude Runs to Stills	Percent Operated of Total Capacity Reporting	Total Motor Fuel Stocks	Total Gas and Fuel Oil Stocks
East Coast	100.0	548	89.1	21,607	17,699
Appalachian	85.9	103	80.5	3,339	442
Ind., Ill., Ky.	89.5	508	98.8	13,121	6,216
Okla., Kans., Mo.	81.6	289	84.5	7,312	4,336
Inland Texas	50.3	117	73.6	1,590	2,110
Texas Gulf	89.5	855	95.5	9,325	10,449
La. Gulf	97.3	135	93.1	2,453	2,897
No. La. & Ark.	55.0	41	74.5	461	865
Rocky Mt.	54.2	37	57.8	1,580	697
California	90.0	502	67.4	15,114	95,652
Reported	85.8	3,135	85.6	75,902	141,598
Estimated Unreported	.....	345	.....	5,200	3,020
*EST'D TOTAL U. S. JULY 1, '39	.....	3,480	.....	81,102	104,618
*EST'D TOTAL U.S. JUNE 24, '39	.....	3,430	.....	81,733	141,965
U. S. B of M. *JULY 1, 1938	.....	**3,129	.....	80,408	138,002

*Estimated Bureau of Mines' basis.
**June, 1938, daily average.


Avoid
NEEDLESS
REAMING
AFTER

Activities in the Oil Fields

W. A. Villines, Shawnee, Oklahoma, has opened a new producing zone for the Hazel area of Seminole County with his No. 2 Millsap, in SW NW SW of 23-7-5e. The well is producing from the Calvin sand at a depth of 2680 ft. The well was drilled to a total depth of 4210 ft., was plugged-back to the Earlsboro sand, at which depth it produced 80 bbl. of oil per day, and was further plugged-back to the Calvin sand. Producing from the latter formation the initial test was 150 bbl. of oil per day.

●

Two new pools were recently discovered in Indiana. Al J. Walker and Bruce Martin, of Tulsa, Oklahoma, opened a pool with their No. 1 Oscar Schmidt, in C SE SW of 13-3s-9w, Gibson County, southwestern Indiana. The well was drilled to the McClosky formation, which tested dry. After being plugged-back to the Pittville sand, at 951-65 ft., it produced by natural flow 70 bbl. of oil per day.

The Superior Oil Company of California brought-in a discovery well in C NW SW of 9-5s-14w, Posey County, Indiana. This well, No. 1 Riberye Island, also was drilled to the McClosky, which was found dry. It was plugged-back to the Waltersburg sand and made 14 bbl. the first hour, flowing by natural means.

●

Successful completion of No. 1 Brown by Arthur Brewer, Hartman and Blair, 3½ miles north of the Hittle pool and 3 miles south of the Rock pool, opens a new area for Cowley County, Kansas. Initially the well flowed 20 bbl. of oil per hour from the Arbuckle lime, found at a depth of 3279 ft. and penetrated 1 ft.

●

A new pool has been opened on the Martha prospect in Liberty County, Texas, by the Stanolind Oil and Gas Company. That company's No. 1 Essie Mae Flowers flowed 150 bbl. of 39-deg. A.P.I. gravity oil in 15 hours through 5/32-in. choke. Production is from a depth of 8104-08 ft., casing having been perforated with 15 shots. Casing pressure was 1400 lb. and tubing pressure 1200 lb.

Franklin County, Illinois, has been given a new oil pool by the Gulf Refining Company. That company's No. 1 Hinman, in 19-5e-3e, pumped 199 bbl. of oil and 7 bbl. of salt water on its initial test. Production is from the St. Louis lime. Nearest production is in the vicinity of Ina, south Jefferson County, 6 miles to the north.

●

Discovery of the second oil pool in Schleicher County, Texas, was indicated when Harold B. Opp's No. 1 J. T. Jackson, 4 miles northwest of Eldorado, initially recovered approximately 80 bbl. of 34-deg. A.P.I. gravity oil in five runs of the swab, leaving 700 ft. of fluid in the hole. In addition gas production was estimated at about 200,000 cu. ft. per day. Production is from the Cisco lime at a depth of 4049-61 ft.

●

A recent feature of drilling activities in Arkansas was the extension, 1½ miles west, of the Permian lime field at Magnolia, Columbia County, by Grady H. Vaughan and Associate's No. 1 Jones, NE NE 21-17s-20w. On the initial test the well produced 28 bbl. of oil per hour through 12/64-in. choke, the casing pressure being 1400 lb. and the tubing pressure 1300 lb.

●

A new McClosky lime pool was indicated for McLean County, Kentucky, when H. H. Schwartz's No. 1 Frissee-Traylor, 2 miles southwest of Beech Grove, cored 5 ft. of saturation below 1233 ft.

●

No. 1 Wisniswski of Smith Petroleum Company and Strom-Wagner Trustees, Tallmadge Township, Ottawa County, Michigan, had 1500 ft. of oil standing in the hole at a total depth of 1897 ft., indicating a new field for the state. The well is a wildcat, being 4 miles west of the Walker field, Kent County. Production is from the Traverse lime.

AVERAGE CRUDE PRICES

California		Louisiana	
Kettleman Hills	$1.19-1.43	Rodessa	$1.05
Playa Del Rey	.80-1.16	Gulf Coast	.74-1.20
Coalinga	.70- .90	North Louisiana	.73-1.05
Signal Hill	.80-1.21	Illinois	.95-1.05
Montana	.90-1.10	Kentucky	.90-1.00
Wyoming	.35-1.30	Indiana	.95
Colorado	.90- .98	Ohio	
New Mexico	.77-1.00	Lima	.90
Texas		Michigan	.70- .97
North Central	.71-1.03	Pennsylvania	
Panhandle	.67- .96	Bradford	2.00
West Texas	.53- .95	Southwest	1.65
Gulf Coast	.79-1.28	Eureka	1.59
Darst Creek	.96	Buckeye	1.55
East Texas	1.10	Corning	1.02
Talco	.55	Canada	2.10-2.17
Kansas	.60-1.10		
Oklahoma	.60-1.10		
Arkansas	.73		

DAILY AVERAGE CRUDE OIL PRODUCTION

Data Supplied by A.P.I.

(Figures in bbl. of 42 gal. each)

	[1]B. of M. Calculated Requirements (June)	Week Ended July 1, 1939	Week Ended May 27, 1939	Week Ended July 2, 1938
Oklahoma	450,300	451,950	449,750	376,550
Kansas	152,400	169,100	161,750	143,150
Panhandle Texas		69,000	70,000	64,300
North Texas		86,200	86,500	73,200
West Central Texas		22,500	31,700	28,400
West Texas		218,900	234,150	181,750
East Central Texas		92,300	97,550	88,300
East Texas		372,800	446,250	364,300
Southwest Texas		225,500	259,200	203,850
Coastal Texas		214,950	236,650	188,350
TOTAL TEXAS	1,427,00	1,312,150	1,462,000	1,192,450
North Louisiana		71,650	72,850	79,400
Coastal Louisiana		199,600	195,100	184,250
TOTAL LA.	265,000	271,250	267,950	263,650
Arkansas	54,400	59,000	55,100	51,100
Illinois	174,300	245,200	222,300	145,400
Eastern (not incl. Illinois)	106,400	98,200	99,250	
Michigan	53,400	68,600	63,850	53,450
Wyoming	73,300	67,000	60,700	61,100
Montana	17,300	15,900	14,650	13,650
Colorado	5,000	4,050	3,950	3,750
New Mexico	117,000	106,600	110,500	91,200
TOTAL EAST OF CALIF.	2,806,400	2,869,000	2,971,750	2,395,450
California	577,600	594,000	613,500	663,100
TOTAL U. S.	3,441,000	3,463,000	3,585,250	3,058,550

[1]These are Bureau of Mines' calculations of the requirements of domestic crude oil based upon certain premises outlined in its detailed forecast for the month of June. As requirements may be supplied either from stocks, or from new production, contemplated withdrawals from crude oil inventories must be deducted from the Bureau's estimated requirements to determine the amount of new crude to be produced.

Great Pioneers

LOUISIANA 1803

On December 20, 1803, Louisiana—owned successively by France, Spain, and France again—was ceded to the United States, after purchase from the government of Napoleon Bonaparte. Thanks to the daring of our early national leaders in interpreting the rights given them by the Constitution, and their foresight in realizing the future value of Louisiana, this great oil-producing state was added to the Union at a cost of about four cents an acre.

● PIONEERS in any field are Leaders. They live in the white light of fame, are copied and envied. But—when a pioneer really "leads", he continues to be a *leader*.

Striving against what looked like insurmountable odds, Dowell Incorporated pioneered, and in 1932 perfected Inhibited Acidizing. New products and services vital to the oil-producing industry have constantly been added. They establish Dowell as the leader well worthy of its enviable position.

DOWELL FREE FLOWING ACID emphasizes the importance of Dowell pioneering efforts. The penetrating properties of this acid permit its easy and uniform entrance into the tight pores of the formation. It retains its low surface tension properties in the spent acid solutions, permitting the reaction products to be returned readily and completely into the well. In low pressure formations and tight wells, this new acid has met with outstanding success.

Operators recognizing true *leadership* "Look to Dowell" for products and services that deliver greater production at less cost.

DOWELL INCORPORATED

General Office: KENNEDY BUILDING, TULSA, OKLAHOMA

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Oil men who attend the Golden Gate International Exposition are cordially invited to visit the Dowell exhibit in The Dow Chemical Company booth.

Look to

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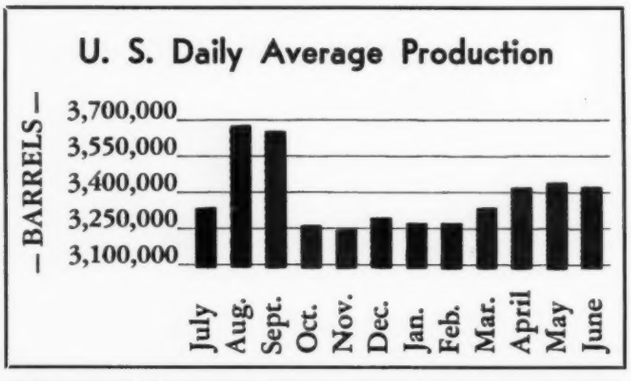
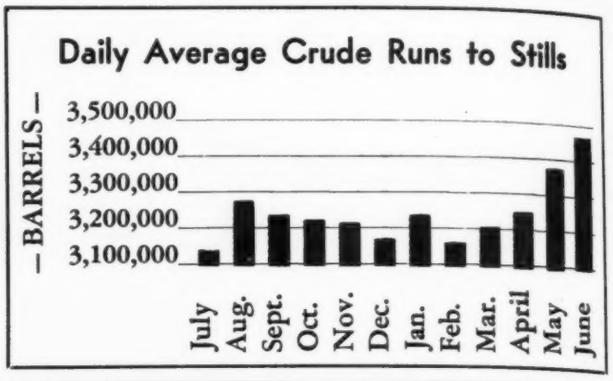
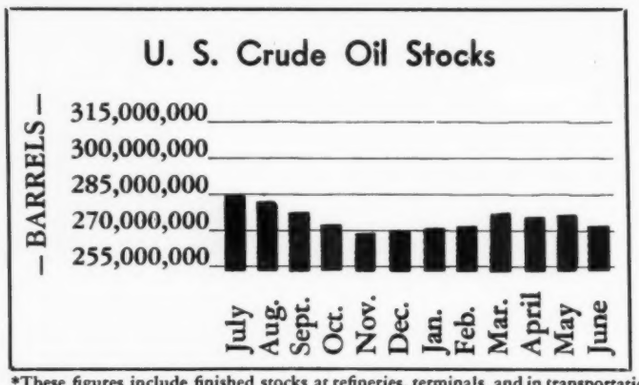
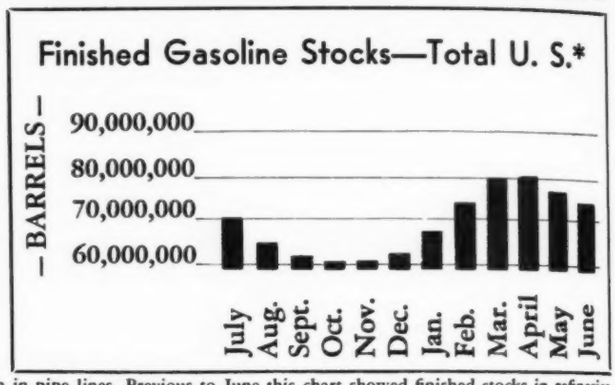
OIL AND GAS WELL CHEMICAL SERVICE

Petroleum Statistics and Field Activities









*These figures include finished stocks at refineries, terminals, and in transportation in pipe lines. Previous to June this chart showed finished stocks in refineries only. Above statistics by the American Petroleum Institute.

Summarized Operations in Active Fields for June, 1939

Fields	Completions	Producers	Rigs	Drilling Wells	Depth of Production	No. Casing Strings	Gravity of Oil	Type of Tool Used
TEXAS								
East Texas	35	35	10	26	3500-3700	2	40	Rotary
Duval County	40	26	3	9	1554-2900	2	22	Rotary
Ector County	39	37	15	52	3675-4377	2 and 3	32-36	Rot.-Cab.
Panhandle	35	34	23	69	1700-3900	2	40	Rotary
Refugio County	16	15	2	9	4900-5900	2	38	Rotary
Nueces County	18	15	2	6	3922-5878	2 or 3	21-54	Rotary
Winkler County	13	13	4	11	2850-3450	2 and 3	30-38	Rot.-Cab.
K. M. A. Field	26	25	28	49	3730-3935	2	42-43	Rot.-Cab.
OKLAHOMA								
Oklahoma City	3	2	1	2	6450-6682	3	30	Rotary
Fitts Pool	15	13	3	9	1800-4488	2 or 3	38	Rotary
KANSAS								
Russell County	19	17	5	31	2926-3435	2 and 5	32-37	Rot.-Cab.
Rice County	21	19	4	18	3222-4085	2 and 5	42-48	Rot.-Cab.
Barton County	10	5	3	12	3290-3518	2	39-42	Rot.-Cab.
ILLINOIS								
Central Illinois	270	201	270	109	1425-4100	2	36-38	Rot.-Cab.
NEW MEXICO								
Lea County	40	37	7	61	3150-4030	3	30-34	not.-Cab.
CALIFORNIA								
Kettleman Hills	2	2	2	12	8300-8730	3 or 4	40	Rotary
Wilmington	15	15	9	20	3500-4000	2 and 3	18-20	Rotary

Field Activities by States for June, 1939

State	Completions		Producers		Locations		Rigs		Drilling Wells		Production, 1938 (In Barrels)
	June	May	June	May	June	May	June	May	June	May	
Arkansas	10	12	9	11	29	24	20	22	32	26	18,211,617
California	94	96	80	81	93	102	75	89	169	179	249,918,001
Colorado	2	2	1	1	....	....	3	2	25	24	1,371,687
Illinois	315	319	251	261	....	....	270	289**	109	122**	23,306,000
Indiana	22	19	9	8	....	....	10	12	56	58	965,900
Kansas	85	113	68	90	172	186	45	42	201	189	58,795,545
Kentucky	75	53	34	27	....	....	10	9	110	96	5,828,650
Louisiana	109	94	74	55	144	149	53	58	187	190	94,941,537
Michigan	130	140	75	82	174	158	20	29	143	141	19,140,966
Mississippi	1	1	0	0	....	....	3	2	4	4	Gas Prod.
Montana	18	11	13	11	....	....	4	5	51	48	4,858,488
New Mexico	55	57	49	47	....	....	17	18	135	129	39,902,263
New York	36*	35*	33*	32*	....	....	11	10	33	32	5,040,600
Ohio	76	82	52	57	....	....	40	41	135	136	3,292,100
Oklahoma	159*	233*	111*	174*	190	229	42	40	318	301	171,312,098
Pennsylvania	99*	109*	91*	103*	....	....	....	....	....	....	17,431,500
Texas	765	837	599	591	988	935	329	267	1123	962	473,304,662
West Virginia	39	38	34	33	....	....	21	20	101	75	3,700,375
Wyoming	10	12	7	8	....	....	6	6	70	69	19,005,638
Total	2100	2263	1590	1672	1790	1783	979	961	3002	2781	1,206,827,597

*Includes water-intake and pressure wells.
**Includes 239 rigs standing and 50 rigging-up.

NIXON

the OUTSTANDING gas-lift system

The Nixon Surface Control Gas-Lift System is in the forefront of the gas-lifting field because it offers certain very definite advantages that entitle it to this prominent position.

Number One of these advantages is SURFACE CONTROL. The volume of flow; the point of its origination are controlled, and can be changed at any time, by equipment on the surface.

The second advantage is KNOWN FLOW LEVEL. At the time of installation it is determined through which flow valve production shall originate, and unless changed, it is through this valve only that gas enters tubing to raise fluid to the surface.

Flow valve is operated AUTOMATICALLY BY MECHANICAL MEANS. A weight bar suspended by wire line from pressure operated piston opens and closes the flow valve. This is the only way possible for the valve to be opened. Standing valve in bottom of tubing prevents fluid-raising pressure from reaching productive sand.

NO OFF-PRODUCTION necessary. By means of the intermitter it is possible to accurately control the volume of production. This eliminates the necessity of shutting down to keep production within pro-rated limits.

HANDLES ALL VOLUMES . . . ALL DEPTHS. Production from high or low fluid levels, in either large or small quantities, is handled with equal success by the Nixon System.

Write for NEW BROCHURE, entitled, "The Sun Rises on an Advanced Nixon Surface Control Gas-Lift System," for complete details of modern fluid lifting. Address nearest Wilson Supply Company store or sales office.

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EXCLUSIVE GULF COAST DISTRIBUTORS FOR: Wilson-Snyder Pumps; American Cable Tru-Lay Pre-formed Wire Rope; Kewanee Boilers; Sievers Reamers; Drift Meter, Jr.; Gray Swivel; Nixon Surface Control Gas Lift; Nixon True-Taper Slip and Spider; Bowen Pack-Off and Releasing Drill Pipe Overshot; Douglas Weight Indicator.

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Complete line of Fishing Tools and Service

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BRANCH STORES:
TEXAS: Gladewater; Barbers Hill; Bay City; Alice; Victoria; Corpus Christi; Benavides.
LOUISIANA: Rodessa; Lake Charles; New Iberia; Gretna.
ARKANSAS: Magnolia.
SALES OFFICES — Tulsa, Oklahoma; Dallas, Texas; Shreveport, Louisiana.

Major Pipe Line Activities

CONSIDERABLE interest has been created by the recently announced plan of the Standard Oil Company of Indiana to build a gasoline line from its refinery at Kansas City, Missouri, to Council Bluffs, Iowa. The 185-mile, 8-in. line will add materially to the total facilities for piping gasoline in the general vicinity of Kansas City. The fact that Standard of Indiana, one of the largest refiners and distributors of refined products in the Middle West, has selected this means of transporting gasoline indicates the growing importance of pipe-line transportation in the modern pattern of refined-product shipment.

●

Under construction in Illinois is a 122-mile, 10-in. oil pipe line being built for The Texas-Empire Pipe Line Company by Williams Brothers Construction Company, Tulsa, Oklahoma. The line is being laid from the Salem field northward to the company's main line at the Heyworth pump station near Bloomington, Illinois. The new line will provide the company with a more direct outlet from the new fields in the Illinois Basin than it has had heretofore. Since last fall, when the Central States Pipe Line Company completed its 8-in. line from Salem to Lawrenceville, Illinois, the Texas-Empire has been taking oil from the latter line at Lawrenceville and pumping it to Heyworth through the line constructed originally to deliver oil to the Indian Refinery at Lawrenceville.

●

In McPherson County, Kansas, Bay Petroleum Company is laying 11 miles of 4-in. oil line from its refinery at McPherson to the Roxbury pool. This will be the first and only pipe line serving this pool. Heretofore, production from the field has been moved by trucks. At the present time there are four producing wells in the field but others may be drilled now that an outlet has been established. As a part of the construction program, a pump station will be built in the field.

●

A portion of one of the oldest lines originating in the Illinois area, the Tide Water 8-in. line from Stoy, Illinois, eastward, has been purchased by the Standard Oil Company for the benefit of its pipe-line subsidiary, the Sohio Corporation. The new owner will soon take over operation of the line from Stoy across Indiana and Ohio to the first pump station within the state of Pennsylvania.

Constructed in 1910, the line has served as a transporting medium for oil produced in the older Illinois fields. The development of production in the newer fields of the Illinois Basin has made the line an important link in the network of pipe lines serving the area. At Stoy, oil may be transferred from the Texas-Empire's Heyworth-Lawrenceville line or from the Illinois Pipe Line Company's system to be pumped eastward into the Pennsylvania and New York areas.

Sohio is also laying a 10-in. line from Noble, Illinois, to Stoy that will serve as an extension of the older line into the edge of the new area and provide a much-needed outlet for production from the Noble field.

●

The importance of Detroit as a market for natural gas is indicated by the construction of two sections of looped-line by Michigan Gas Transmission Corporation, the company organized to take gas from the Panhandle Eastern Pipe Line Company at the Indiana-Illinois state line.

One of the loops will be a 24-in. starting at the above-mentioned delivery point and extending eastward 10 miles to the company's Montezuma station. Another 24-in. loop, 6 miles in length, will extend eastward from the east header of Raccoon Creek crossing. Involved in the first loop will be a crossing of the Wabash River, requiring two 16-in., each approximately 1 mile in length.

●

A new 6-in. gas line, approximately 18 miles long, is being laid by United Gas Pipe Line Company, Houston, Texas. The line will cross the Sabine River, originating in the Joaquin area in the extreme northeast corner of Shelby County, Texas, and will terminate near Mansfield, DeSoto Parish, Louisiana. Gas for the line will be supplied by the recycling plant in the Joaquin field owned by the Portex Oil Company. The processing load on the Portex plant may be increased in the near future by the construction of lines connecting wells near Logansport.

●

Two parallel lines, 14 miles in length, are planned by the Lion Oil Refining Company, El Dorado, Arkansas. The lines will originate at the company's refinery at El Dorado and serve to pipe refined products to a river terminal at Champagnolle, Arkansas, on the Ouachita River. One of the lines, an 8-in., will be used to transport fuel oil; the other, a 6-in., will carry gasoline. This arrangement will permit a substantial portion of the refinery's output to be loaded into barges and shipped down-river to market.

●

The Cities Service Gas Company has announced plans for the construction of an 8-in. line approximately 40 miles in length, to extend from the Cunningham field, Kansas, to connect with the company's system at Hutchinson, Kansas. The line will have a capacity of 20,000,000 cu. ft. per day. Most of the pipe will be supplied from company warehouses and from reclaimed lines. The laying of the line will be by company personnel under the supervision of H. B. Milam, superintendent of the pipe-line department.

P 538.25

THE Petroleum Engineer

JULY, 1939

A PETROLEUM ENGINEER FEATURE

Chemical Aspects of Water-Flooding

Close control of pH value and alkaline content permits corrosion protection of metal equipment without precipitation of salts underground

By RAYMOND NAUTH
Consulting Petroleum Engineer

IN the years since the discovery of oil in the Pennsylvania fields, production men have exercised much ingenuity in obtaining additional oil production at reasonable cost beyond the yield to be expected in the normal exhaustion of a reservoir.

During the early years, ordinary pumping was all that was needed to obtain a satisfactory rate of production. As production declined, operators turned to experiments with various methods of secondary recovery in an effort to prolong the economic life of the fields. It has been estimated that even after a property has been subjected to secondary recovery more than half the total oil still remains in the oil sand unrecovered. Consequently, there has been ample incentive to devote much time and money in an attempt to increase recovery.

In the Bradford field, about 20 years ago, the now-famous "five-spot" plan for water-flooding was first introduced. This method was more or less successful in increasing recovery and considerable interest was stimulated in its possibilities.

In the Titusville-Warren-Oil City area farther south, a 7- or 9-spot scheme was adopted in the initial effort to employ gas as the driving medium and here, too, good increases in production were obtained. In recent years, the use of some of the recovery methods that were developed in Bradford has extended to fields in the Mid-Continent and elsewhere.

Historical Notes on Recovery Processes

As early as 1875, Lyman Stewart of Titusville was granted a patent to improve oil wells, but even in 1874 E. McCauley Stevenson had undertaken to increase production in wells by inserting a steam pipe into a well in the hope that the heat of the steam would help eject the oil contained in the well. (U. S. P. 166,426.)

In 1886, a patent was granted to Thurston Hall of Niagara Falls, who also proposed to inject steam into a well. He planned to add to the steam a mixture consisting of 88 parts of common salt, 10 parts of flower of sulphur, and 2 parts of ammonium chloride to bleach and refine the oil. The steam was to be introduced into the well at a pressure of 1500 lb. per sq. in. (U. S. P. 345,586).

William Mooney, in 1900, obtained a patent on the idea of increasing production by cleaning a well periodically (U. S. P. 657,951). Not many oil men today are aware that clean-out work in an oil well was once covered by patent.

The Smith-Dunn process of injecting compressed-air as used even today in some Pennsylvania fields, was introduced at the beginning of the century.

RAYMOND NAUTH

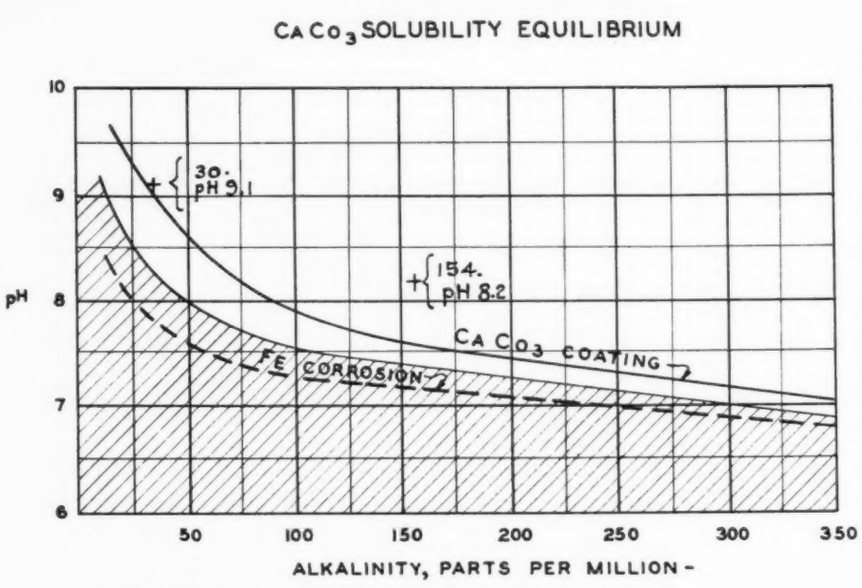
resides in Buffalo, New York—Has a bachelor's degree in electrical engineering from the University of Wisconsin and a doctor's degree from the University of Toronto—Has engaged in consulting petroleum engineering work for many years—Is the holder of 12 U. S. patents relating principally to the refining of tar and tar oils and gas and oil production methods.

In 1922, Robert E. Lee (U. S. P. 1,439,560), proposed the use of steam to clean oil and gas wells, presumably to melt paraffin residue if present.

William Russel of New Haven was granted a patent (U. S. P. 1,658,305) in February, 1928, for forcing alternately a liquid and a gas into an oil stratum, in conjunction with the present "five-spot" water-flooding method.

In 1931, R. E. Lee (U. S. P. 1,816,-260) proposed to drill horizontal holes outward from the vertically-drilled hole and pump a super-heated medium into these holes.

Fig. 1



NOTE : CORROSIVE WATER INDICATED BY SHADED AREA.

In 1932, K. Kelly of Houston, Texas, and Samuel Perkin of Sulphur, Louisiana, recommended forcing superheated water, sodium hydroxide, and mud into wells. They planned, by this scheme, to soften the waxes and viscous oils and lift them by volatilization of the light fluids.

These are but a few of the hundreds of methods for increasing recovery that have been advanced by various men during the last 50 years.

Purity of Water In Flooding Operations Important

L. J. Bradford[1] first called attention to the importance of analytical control of floodwaters in the Bradford field. When water-flooding was introduced many producers did not realize that the impurities of water being forced into the input wells might cause trouble. It was only after many producers had experienced discouraging results that the importance of chemical treatment of the water put into the input wells was recognized.

Obviously, if the water is directly responsible for the movement of the oil through the sand, any factors that inhibit or prevent this movement will reduce the output of oil. It does not require very much solid material to block the small interstices of an oil-sand. A water that appears pure and clear may be quite unsuitable for use.

In the Bradford fields the present trend is toward treatment of input water to prevent corrosion of fittings, pipes, etc. Corrosion of iron pipes is caused principally by oxygen dissolved in the water. Other factors affecting corrosion are carbon dioxide, and dissolved salts.

Iron reacts with water, liberating hydrogen, which would form a protective gaseous coating on the inner surface of the pipe if it could remain undisturbed in a free state. Actually, however, the oxygen dissolved in the water combines immediately with the hydrogen and contributes to the formation of ferric hydroxide. Ferric hydroxide is highly corrosive and contributes to the formation of tubercles on the pipe wall. As these tubercles break off, a pit is formed and as the process is repeated the pit deepens until it penetrates the pipe wall.

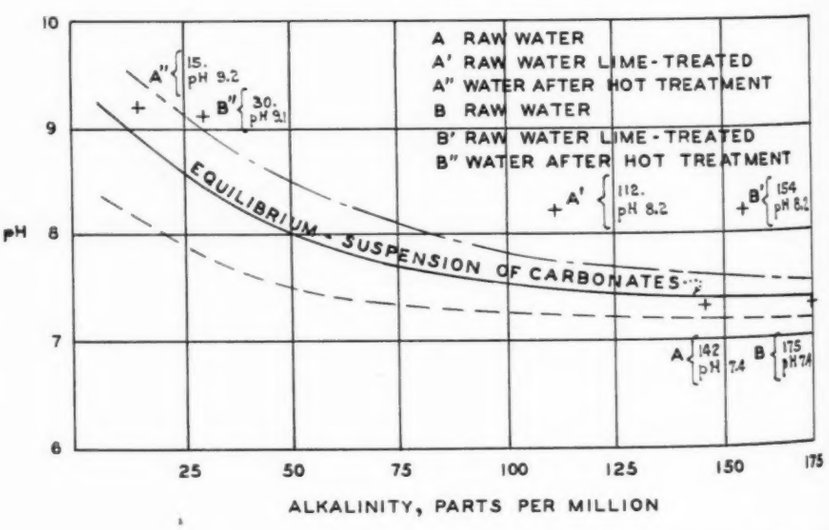
If the water contains components of slight solubility such as calcium carbonate in sufficient quantity, they may be precipitated by the products of corrosion, and form a lining on the inner pipe surface. This coating is effective in preventing further metal-attack by the water. Actual experience has shown that water having a low pH value falling below the Baylis solubility-equilibrium curve (Fig. 1) will be corrosive to metal. Consequently, such waters may be treated with calcium hydroxide, which reacts with the carbon dioxide in the water to form the bicarbonate that precipitates into a protective coating for the pipe.

This curve by Baylis shows that the equilibrium solution of calcium carbonate in distilled water ranges from 10 p.p.m. when the pH value is 9.2 to 350 p.p.m. when the pH value is 6.8. It is obvious that the addition of other salts will affect the position of this curve. For instance, addition of 10 parts of magnesium carbonate to the water will enable it to dissolve 98 p.p.m. calcium carbonate when the pH value of the solution is 8.0, instead of only 50 p.p.m.

The present practice of treating water with lime in the Bradford area is based on the fact that local waters contain dissolved CO_2 and the solubility of calcium carbonate depends on the amount of carbon dioxide in the water. As CO_2 is absorbed, the saturated water becomes super-saturated and calcium carbonate is precipitated until equilibrium is again reached. Consequently, the piping carrying such treated water receives a protective coating of $CaCO_3$. This method is used widely in the Bradford fields at the present time but, unfortunately, it possesses some bad features. One is the variability of the CO_2 content of the water with seasonal changes. Another

[1] *Ind. Eng. Chem.*, July, 1927.

Fig. 2



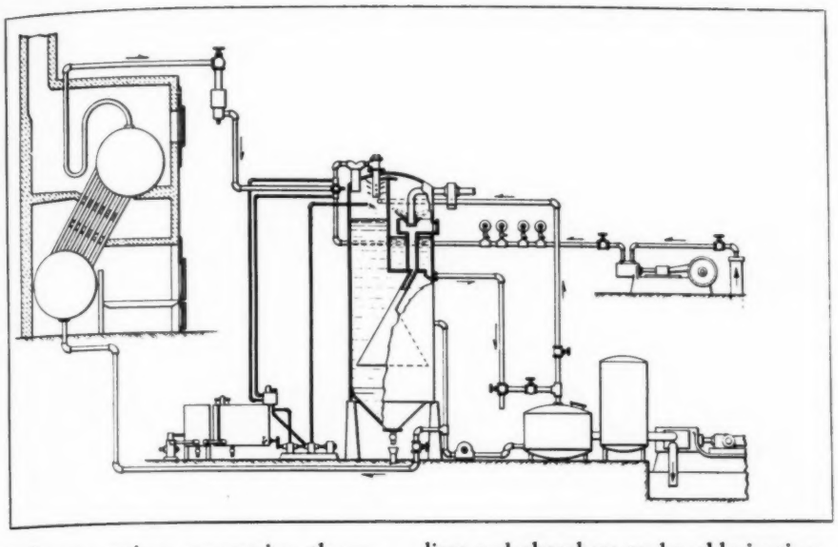


Fig. 3

is the uncertainty concerning the reactions occurring when these waters are released in the oil sands underground. Saturated solutions, which may tend to become supersaturated underground as the pressure declines from the input well toward the producing well, are objectionable because the precipitation of carbonates may clog the interstices of the sand. This objection may be eliminated, in part, by a close control of the pH value of the solution without losing the protection afforded to the piping by the precipitated coating.

Fig. 2 illustrates the results of water treatment. Raw water that has an alkaline content of 142 p.p.m. and a pH value of 7.4 (point A) is definitely a corrosive water because it falls below Baylis' curve. Treated with lime, this water has an alkaline content of 112 p.p.m. and a pH value of 8.2 (point A'), and is now non-corrosive and capable of coating the inside wall of the pipe. If the water is further treated, however, the alkalinity is reduced to 15 p.p.m. and the pH is increased to 9.2. This solution will still result in a slight coating but the possibility of precipitation underground will be slight.

It will be seen, therefore, that the amount of carbonate deposited is reduced by advancing toward a higher pH on the equilibrium-solubility curve. It is assumed that a small carbonate coating, be it ever so slight, must be formed on all water lines to prevent corrosion. The results in the present practice of introducing saturated water having an alkalinity of 110 p.p.m. and a pH value of 8.2 can be improved by altering both the pH and alkalinity values to a new equilibrium point. Fig. 3 is a diagram of the equipment necessary to effect this change to a high pH value and a low carbonate content. Equipment needed includes a boiler, lime and phosphate tanks, chlorinating apparatus, filter, deaerator, storage tanks, and high-pressure pumps. Briefly, the process is as follows:

If necessary, the water is treated with chlorine to kill any organisms. In the mixing valve suitable amounts of lime, soda, and steam are mixed with the incoming water. The steam aids the reaction and thoroughly mixes the lime and soda with the water. The water is held in a settling tank for 45 minutes to provide time for the precipitated carbonates to settle. The sludge is removed by a pump from the settling tank. The relatively clear water then passes upward through the funnel arrangement and flows into a trough where it is mixed with steam to deaerate the water, removing the oxygen and carbon dioxide. The water then flows into a small tank from which it passes to a non-siliceous filter, which removes any flocculant particles. From the filter the water goes to the storage tank, ready for distribution. Schematically, the path of the water is as shown in Fig. 4.

Tests show that the desired alkalinity can be held within 2 grains per liter plus or minus. Repeated tests over a long period of time show that by this method the pH of water containing less than 15 p.p.m. can be maintained between 9.2 and 9.4 under continuous operation, insuring a noncorrosive water and requiring limited attention from the operator of the treating plant.

The saving effected by treatment in the above manner may be expressed as follows:

pH	Alkalinity, p.p.m.
8.	50
9.2	15

Saving: 35 p.p.m. not put into wells.

This saving may be translated into more practical terms as in the following example:

10 wells receive 550 gal. of water per day, a total of 5500 gal. per day, or

1,650,000 gal. in 300 days.

At a pH of 8 and alkalinity of 50 p.p.m. this volume of water would contain 330,000 grams of $CaCO_3$.

If, however, the pH is 9.2 and the alkaline content is reduced to 15 p.p.m. only 99,000 grams of $CaCO_3$ will be introduced.

330,000 grams at pH 8. and alk. 50 p.p.m. (727.51 lb.)
— 99,000 grams at pH 9.2 and alk. 15 p.p.m. (218.03 lb.)

231,000 grams of $CaCO_3$

Thus, by the older method, 727 lb. of $CaCO_3$ will be forced into the sand or 72.8 lb. per well in 300 days.

In the improved process, only 218 lb. of $CaCO_3$ will be introduced into the sand, or 21.8 lb. per well, a total saving of 509 lb., or 51 lb. per well. This saving will retard the plugging of the sand in direct proportion to the net reduction in calcium, will facilitate ingress of the water to the sands and, thus, will increase oil recovery.

Additional benefit results from adding chlorine to the raw water to kill organisms before the raw water is filtered through nonsiliceous materials to reduce traces of precipitated material to a minimum. Other salts such as magnesium carbonate may affect the solubility equilibrium of $CaCO_3$ so that an excess of lime is required. The reaction will be: $MgCO_3 + Ca(OH)_2 = Mg(OH)_2 + CaCO_3$, and $Mg(OH)_2$, being insoluble, will precipitate. If $MgCl_2$ is present, the reaction will be $MgCl_2 + Ca(OH)_2 = Mg(OH)_2 + CaCl_2$. In this case, $Mg(OH)_2$ will precipitate the $CaCl_2$ as well as any unattacked chlorides, nitrates, or sulphates that the lime did not attack.

Thus:

$CaCl_2 + Na_2CO_3 = CaCO_3 + 2NaCl$

or $CaSO_4 + Na_2CO_3 = CaCO_3 + Na_2SO_4$.

Thus, this process of chemical treatment is adaptable to most types of water. Analysis of each water is necessary to determine the amount of chemical to be added. Reviewing, the necessary steps in treating water by the above process are:

(1) Before a definite schedule of treatment is planned, the raw water is tested.

(2) Lime is added and its effect on alkaline content and pH value is determined.

(3) The result of the determination in (2) dictates the length of the hot process cycle required to precipitate

sufficient dissolved material to reduce the alkalinity to 15 p.p.m. and increase the pH to 9.2.

Several features have been discovered as a result of experience in injecting water into wells.

(1) When warm water as received from the hot filter is injected, there is an increase in production of oil.

(2) When warm water is used, the life of wells is prolonged because of the lesser deposition of alkaline earth salts in the interstices of the oil-bearing rock; there is less pressure-drop of the water in the sand and oil recovery is increased thereby.

(3) Inasmuch as the water contains only a small amount of dissolved minerals, it is possible to superheat this water before sending it down into the oil sands under pressure.

Superheated water vaporizes and expands the oil forcing it toward the producing well.

In weighing the present method of cold water treatment against methods of using superheated untreated water of medium pressure, or of using the addition of NaOH at the point of injection of warm water into the input well, it is now possible to eliminate all the ill effects of previous methods of applying superheated water to oil wells, and to improve the present cold water method by employing the further treatment here described.

The sands in old wells that have been pressured with highly alkaline lime-treated waters sometimes contain carbonates held in the form of bicarbonates due to the CO_2 content of the water. When a deareated water having an alkaline content of 15 p.p.m. and a pH value of 9.2 is injected into the sands it will absorb any CO_2 present in the water from previous pressuring methods. This reduction in total CO_2 content would result in an increase in precipitated carbonate in the sands. This point deserves serious consideration when the new treating process is used in existing pressure systems.

To prevent the precipitation of carbonate or to convert the carbonate into the bicarbonate, enough CO_2 must be added to dissolve the carbonate and to insure that the solubility product of calcium carbonate is no longer exceeded.

Several methods can be used to introduce CO_2 into the water:

1. Add the exhaust gases from the engines or boilers by means of an injection through a small pipe into the well.

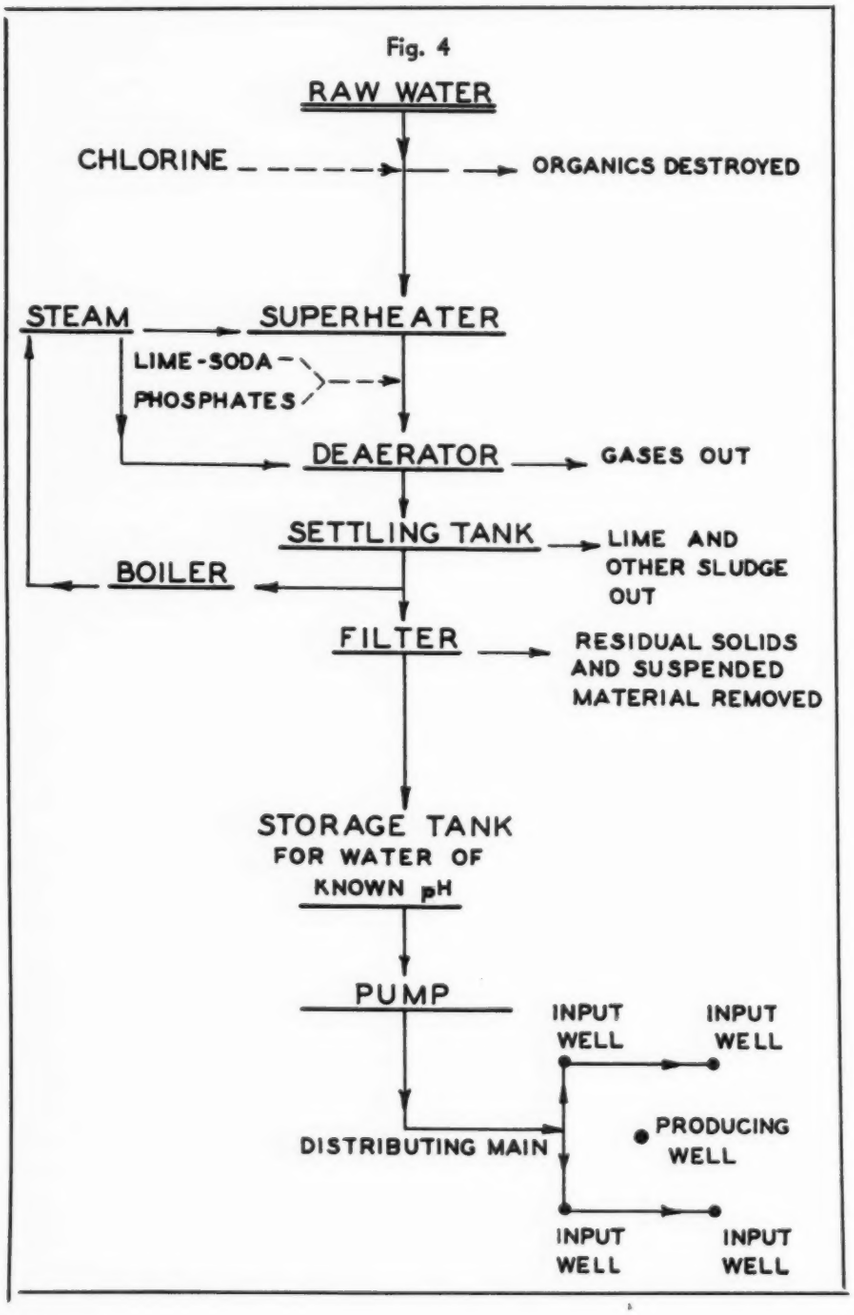
2. Drop crushed or snowy ice directly into the input wells.

3. Add acid. This is expensive, however. It will be seen that precipitation of carbonates resulting from addition of lime to the water may, in some wells, cause sudden stoppage of oil production.

It should be noted that introduction of carbon dioxide is not always the remedy to be used in treating all wells showing an increase in pump pressure. Special treatment of a different type is sometimes required to dissolve calcite or aragonite crystals that may have formed in the sands. The problem requires a careful consideration of the chemistry of water-treating and an expert application of the remedy after a correct diagnosis and plan of attack has been developed.

For such fields as Titusville, where use of water-pressuring alone has never been quite successful, it is suggested that cold water be used that contains a large content of CO_2. Plain water has never been successful there. This same method is also applicable to some of the sands in the Mid-Continent and southwestern fields. Such a water may be injected for a period of a week to a month and then followed by a week's injection of a small amount of steam deep in the well. The heat of this steam will release the carbon dioxide in the water, which will tend to release the oil trapped in the upper interstices of the sand, an accomplishment heretofore not possible using air, gas, or water under the schemes now in use.

Fig. 4



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Acid Treatment of Sand Wells in Gulf Coast Fields

New surface tension reducing agent extends application of acid treatment in fine-grained sandstones

By H. LEE FLOOD
Associate Editor

THE success that has attended the use of acid in increasing production from limestone formations has caused operators in sandstone areas to wish enviously for a similar technique that would prove as valuable in increasing porosity and permeability of "tight" sandstones. The Gulf Coast area of Texas and Louisiana, predominantly a sandstone area, and long a prolific and important producing area, would stand perhaps to profit most from such a development. In fact, the area is now receiving the benefits of acid treatment in sand wells. Several interesting methods have been used that indicate acidizing may become as standard a practice in sandstone areas as it now is in limestone areas.

To avoid any misunderstanding, it should be noted that the acid used is no new product developed to dissolve miraculously the silica of sandstone as the carbonate of limestone is dissolved. Desirable as such a chemical may be, it is not believed at present that a reagent may be developed that will react on silica to increase sand porosity.

Development of Acid Treatment of Sand Formations

The first successful treatment of a sand well on the Gulf Coast was in 1937. This initial treatment was undertaken only after a thorough investigation in the laboratory of the effect of acid on core samples of sandstones of varying solubility. As a result of these experiments, it was found that acid could be used effectively in formations either of very high solubility or of very low solubility. Highly soluble formations are, of course, limestones, dolomites, and other carbonates. Formations containing only small percentages of soluble material include sandstones in which there is only a trace of carbonates. Sandstones containing from 30 to 60 percent of soluble minerals as cementation material are not suitable for acid treatment because the dissolved material completely destroys the structure of the sandstone, often resulting in the creation of a loose unconsolidated sand that may pack so tightly that commercial oil production is not obtainable. Fortunately, most of the oil-bearing sandstones in the Gulf Coast area are of low solubility, usually less than ten percent so that acid may be used to advantage.

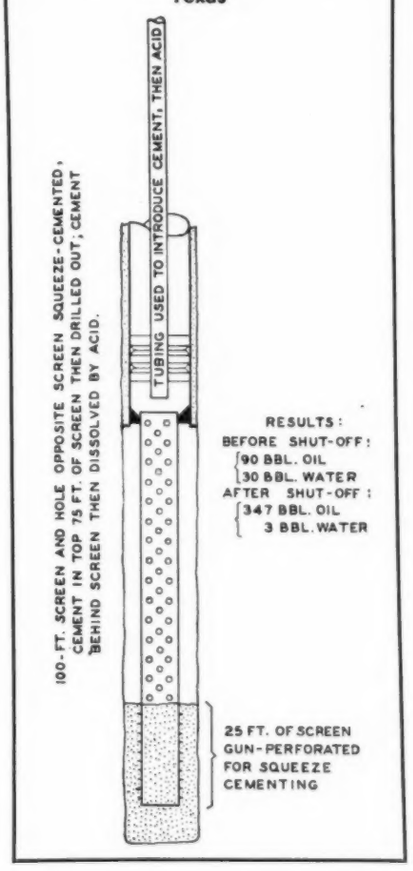
Effective Surface-Tension Agent Developed in Gulf Coast

One direct result of acid treatment in the Gulf Coast has been the development of a new surface tension reducer that has enhanced the efficacy of acid treatment in general.

Surface tension reducing agents of many types have been used. Many of these permitted a reduction of the normal surface tension of acid of approximately 75-77 dynes per cm. to a value of about 50 dynes per cm. The drawback in most of these agents has been the failure to retain this lower value during the action underground. In other words, the lowered surface tension would be beneficial during the introduction of the acid but when needed most, during the removal of the spent acid, the surface tension would have resumed its normal value.

The new surface tension reducer introduced on the Gulf Coast has the ability to reduce the surface tension of acid to approximately 26 dynes per cm. More important, it does not "break-down" during the reaction but maintains a low surface tension substantially without change.

Water shut-off in the Conroe field, Texas


100-FT. SCREEN AND HOLE OPPOSITE SCREEN SQUEEZE-CEMENTED; CEMENT IN TOP 75 FT. OF SCREEN THEN DRILLED OUT; CEMENT BEHIND SCREEN THEN DISSOLVED BY ACID.
TUBING USED TO INTRODUCE CEMENT, THEN ACID
RESULTS:
BEFORE SHUT-OFF:
90 BBL. OIL
30 BBL. WATER
AFTER SHUT-OFF:
347 BBL. OIL
3 BBL. WATER
25 FT. OF SCREEN GUN-PERFORATED FOR SQUEEZE CEMENTING

Applications of Acid To Sand Wells

Acid is being used principally to "clean-up" sand wells in the Gulf Coast. In the short time acid has been available in this area, wells have been treated in various fields extending from Corpus Christi, Texas, to New Orleans, Louisiana. Treatments have been made on both old and new wells.

Removing cement. One of the most frequent applications of acid treatment has been in cleaning-up cement back of gun-perforations in new wells. Occasionally, also, it is necessary to resort to acid in connection with squeeze-cementing jobs in older producing wells.

One of the most interesting jobs of the latter type was completed recently in the Conroe field, Texas. The well was producing through a 100-ft. screen hung in the lower end of the casing string. Fluid production had been averaging 120 bbl. a day, of which 25 percent was water. Water was coming from the sand opposite the lower 25 ft. of the screen. Planning to obtain a water shut-off, the lower 25-ft. section of the screen was gun-perforated in order to gain entrance through the screen for cement.

After it had set, the cement inside the upper part of the screen was drilled-out leaving the lower 25 ft. filled with cement. Following this, acid was introduced into the screen under pressures varying from 800 to 1400 lb. per sq. in. The acid was effective in cleaning-up the screen and in dissolving the cement behind the screen. Apparently, it had a beneficial effect on the sand formation itself for, in addition to aiding in obtaining a water shut-off, an increase in oil production resulted. The accompanying sketch depicts the underground arrangement in this well.

Cleaning-up screens and sand-faces. Corrosion and clogging of screens is one of the most irritating and also most costly production problems in the Gulf Coast. In the majority of instances, heavy mineral content of the oil or water entering the well-bore is deposited on the screen and in the sand adjacent to the well-bore. Screens become so badly incrusted and so firmly cemented that it is necessary to cut them out in small sections in order to remove them.

Acid has proved effective in dissolving these mineral deposits, a large part of which is carbonate and susceptible to acid attack. Not only does the acid serve to clean the screen of the amount of incrustation usually observed when a screen is removed but it penetrates into the sand and cleanses the entire clogged section of the formation.

One characteristic of oil formations adjacent to salt domes is the heavy mineralization usually occurring over the apex of the dome. Acid has been used successfully to reduce this mineral content in reconditioning wells so situated on the dome.

De-mudding operations. Acid has been utilized as a valuable means of removing drilling mud from newly-completed wells. In the Gulf Coast area, the predominant method of well completion is to set casing on bottom. While the hole is filled with mud the casing is gun-perforated, a screen is set, and then the mud is circulated-out of the hole using water.

The value of acid in mud-removal was demonstrated recently in a well situated in one of the Louisiana Gulf Coast fields. The operators of the newly-completed well had used various means to establish production from a formation that had shown every indication during drilling of containing oil but it had become mudded-off until there was no longer even a slight show. As a last effort to establish production, acid was employed. More or less convinced that the oil production, if any, would be small, no provision was made for pressure control. After the acid treatment, the well was swabbed a couple of times and the well blew-in unexpectedly. After blowing out-of-control for about six hours, the well was killed by pumping mud into the casing. After proper provision for control of pressure had been made, the mud was removed from the hole. The well was swabbed repeatedly but the production could not be brought back. Acid was again used in the well to de-mud the formation and the well again blew-in. This time, however, the production was under control and the well continued producing.

Future of Acid Treatment in the Gulf Coast

The results to date of acid treatment of sand wells in the Gulf Coast indicate that the method will continue to receive a wide acceptance in this area. In addition to its efficacy in disintegrating mud and cement in new wells, its application even in old wells that have been producing for years, has been successful in removing mud and cement lodged in the well since it was drilled.

Results of Some Typical Gulf Coast Acid Treatments in Sand Wells

Well no.	Purpose of chemical treatment	Chemical used, gal.	Maximum treating pressure, lb. per sq. in.	Oil production, bbl. per day		Remarks
				before treatment	after treatment	
1	Workover to reduce gas-oil ratio and to clean-out gun perforations. Had been squeezed and gun-perforated with 160 shots. Would not flow.	1000	1500	Well dead, no flow	100 (gas-oil ratio 2000)	Well had been squeezed over 10-ft. section and perforated several times. Fluid or gas would not enter well. Cement and mud probably stopped-up gun perforations.
2	To wash gun perforations	900	1000	None	2500 (est.)	Well had been plugged-back to upper producing zone as shown by electrical log—squeezed above and below—no flow after perforating and swabbing for several weeks.
3	To remove secondary mineral deposits and mud from sand—new well.	1500	1400	10	300	Casing set through producing zone which was hard and dense due to secondary mineral deposit in sand pores.
4	To clean screen and sand formation in old pumping well.	1000	1500	5	32	Well had steadily declined over period of years due to plugging action of "scale" or mineral deposits.
5	To clean formation near screen in pumping well.	1000	1200	4	20	Well had been plugged-back and pipe perforated at level of upper producing zone. Probably some cement involved.
6	To remove cement and mud ahead of gun perforations.	1000	5000	None	undetermined amt. of water and gas	Formation contained only water and gas.
7	To open up gun perforations after squeeze job.	1000	3200	None, swabbed dry	100	Well had been worked-over to reduce gas-oil ratio. Would not flow following cement squeeze job and gun perforation.
8	To remove sleeve of cement over pay section using "acid jet-gun"; pumping well.	750	600	Bailed dry	15-20	Formation was inadvertently squeezed off below casing seat. Size of bit used to drill-out considerably smaller than diameter of open hole.
9	To clean-up and remove cement and mud following gun perforations.	1000	1600	no flow	180	Entire pay section had been squeezed-off to reduce abnormally high gas-oil ratio (60,000). After drilling-out cement plug, well would not flow.
10	To de-mud well after setting screen.	1000	2400	swabbed dry	150	Well had been killed by 14-lb. mud to set screen. Would not flow after screen was set. Responded immediately after chemical de-mudding treatment.

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High Rotating Speeds Employed in Drilling Deep California Well

Speeds as great as 600 r.p.m. attained in drilling to a depth of 12,375 ft. in fast time

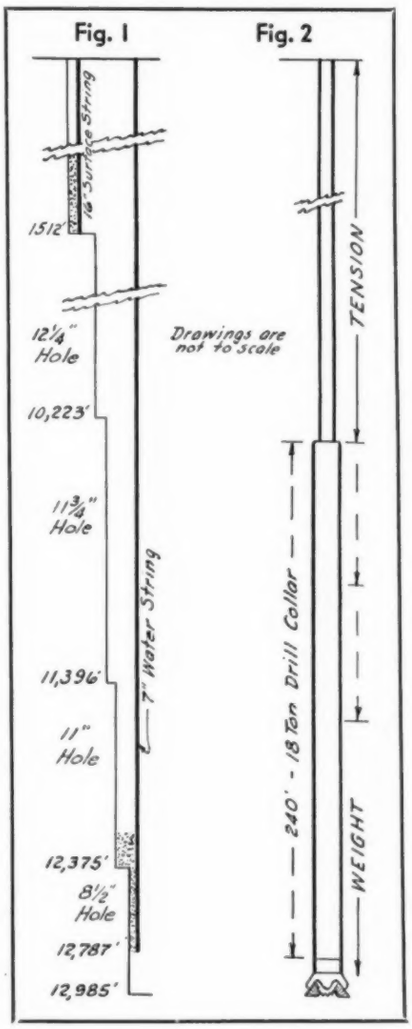
By WALLACE A. SAWDON
Pacific Coast and Foreign Editor

THE technique of high-speed rotation has probably been advanced to a greater extent in drilling deep wells in the San Joaquin Valley, California, than in any other area in the world. Drill pipe rotating speeds of 400 r.p.m. and greater have become more or less common in the Rio Bravo field; a rotating speed of 600 r.p.m. has been employed in one operation in nearby territory. This speed was used mainly in testing and actually was applied in making only a small amount of hole.

The use of high rotating speed involves considerably more than the mere rotation of the table at great speed. Many engineers are of the opinion that such high speeds are not practicable using present types of equipment. Rotary machines as now designed have a rated speed of not exceeding 350 r.p.m. Yet these tables have been used successfully at the high speeds now being applied; other equipment directly or indirectly affected has also played a definite part in making high speed effective.

The present trend in high-speed rotation is exemplified by Union Oil Company's No. 1-36 Kernco, between Shafter and Wasco, California. In drilling this well a speed as great as 600 r.p.m. was attained although little actual drilling was done at this speed. To a depth of 4000 ft., however, the drill pipe was rotated at more than 575 r.p.m. and to 7000 ft. the rotating speed was more than 500 r.p.m. From 7000 to 8000 ft. the rotating speed was 400 r.p.m.; from 8000 to 9000 ft., 375 r.p.m.; and from there to 12,375 ft., when continuous coring started, table speed was maintained at 300 r.p.m. or more. In coring from 12,375 ft. to a total depth of 12,985 ft., rotation averaged approximately 150 r.p.m. Moreover, open hole was carried from the bottom of the 16-in. surface string cemented at 1512 ft. to a depth of nearly 13,000 ft. An important factor contributing to the success of the operation and to avoiding the need for a protective string of casing was the "step-down" method indicated in Fig. 1 and discussed later.

Whether or not any hole-making record was established, the drilling time on this well is worthy of consideration. A depth of 10,100 ft. was reached in 20 days; 11,200 ft. in 30 days; and 12,200 ft. in 40 days. Surveys were made using a drift recording instrument to measure the inclination from the vertical at regular intervals and the well was thus controlled for verticality. The maximum deviation reported was 1¼ deg. and at the last reading taken (below 12,000 ft.) the inclination was zero. The maximum deviation permitted in the surface hole is ½ deg. In the rest of the hole the inclination is brought back to zero as soon as the record indicates a deviation from vertical. It is believed that the bottom of the hole lies within, or very close to, the projection of the area directly beneath the derrick floor.



When using high speeds, first consideration must be given to the bit. In this particular well, rock bits were used from top to bottom. Not so many years ago bit design and construction would not have permitted rotation at the high speeds now used and even with present design the size, according to the opinion of one operator, is instrumental in the performance. The bearings of the bit have to withstand the weight and speed applied and it was believed in planning the operation that rock bits of 11¾ to 12¼ in. would be most satisfactory for the rotating speeds contemplated for this well.

Considerable credit for drilling the hole so straight at rotation speeds of from 500 to 575 r.p.m. was attributed to the use of a 240-ft. drill collar weighing approximately 18 tons. This collar was made up of four 60-ft. lengths of 8¼ in. O. D. All the weight applied to the bit was provided by the drill collar. The drill pipe above the collar was maintained in tension and at some point below the top of the collar, transition from tension to compression was made. (Fig. 2.) The weight indicator used was calibrated to read directly in tons of weight on the bit, having a vernier graduated also to read in tons. The weight on the bit was limited to a maximum of 18 tons (the weight of the drill collar alone) so that the drill pipe could always be kept in tension. Actual weight carried during the drilling was maintained at all times very close to but never more than that of the drill collar. The drill pipe therefore served mainly as a rotating medium and as a means for transporting mud fluid to the bit; and all the

weight carried on the bit was concentrated at the bottom of the hole, thus eliminating flexure of the drilling string and reducing to a minimum the chances for drifting, wear on the drill pipe, twist-offs, etc.

The drill pipe used to 10,375 ft. was made of high-alloy steel, 5 9/16-in. O. D., having internal and external upset joints. Because greater vibration accompanies the use of the square kelly, an octagonal kelly was used. The other advantages of the octagonal kelly, such as providing greater fluid passage both inside and between the kelly and casing, were considered but the main reason for its use was to reduce vibration to a minimum at the high rotating speed employed.

From 10,375 ft. to total depth, 4½-in. high-alloy drill pipe having external and internal upset joints replaced the 5 9/16-in. size. While drilling to 12,375 ft., the 240-ft. drill collar was used above the bit.

Other equipment for use at high rotating speeds in deep wells must be properly designed. Larger pumps must be provided to circulate the greater volume of fluid and swivels must be able to withstand the heavy duty imposed. The 1¼-in. line now widely used on these deep wells necessitates the use of larger sheaves in the crown and traveling blocks and larger drums on the drawworks must be equipped with larger bearings.

Mud circulation was provided by two 15½-in. by 8½-in. by 20-in. steam pumps and the mud was conditioned through two vibrating screens. A blind was installed in the 10-in. suction line to one of the pumps to facilitate compounding when high pressure was required. In addition to its use for circulating mud fluid, the second pump was hooked-up to provide any necessary services such as mixing mud, pumping to the degasser, etc.

One 15½-in. by 6¾-in. by 14-in. pump was provided for mixing weight material and thinning agent with the mud. This pump also could be used to pump the mud from the well through the degasser. The mud was mixed in a pit and then pumped to a tank for storage.

Another small pump was used to supply water for the drum, for washing, and for actuating the blowout preventer and packer.

The steam generating plant consisted of four 350-lb. boilers having superheaters built integrally. Feedwater pumps and water treaters were placed directly behind the boilers.

It is, of course, impossible to use rotating speeds such as those employed on this well without the use of an individual engine for driving the rotary machine. The one used here was of the underfloor type consisting of a 12-in. by 12-in. twin-cylinder engine direct-connected to an extension shaft by a flexible coupling. From a sprocket on this shaft the rotary table is operated by a chain drive, totally enclosed and lubricated by an oil-bath.

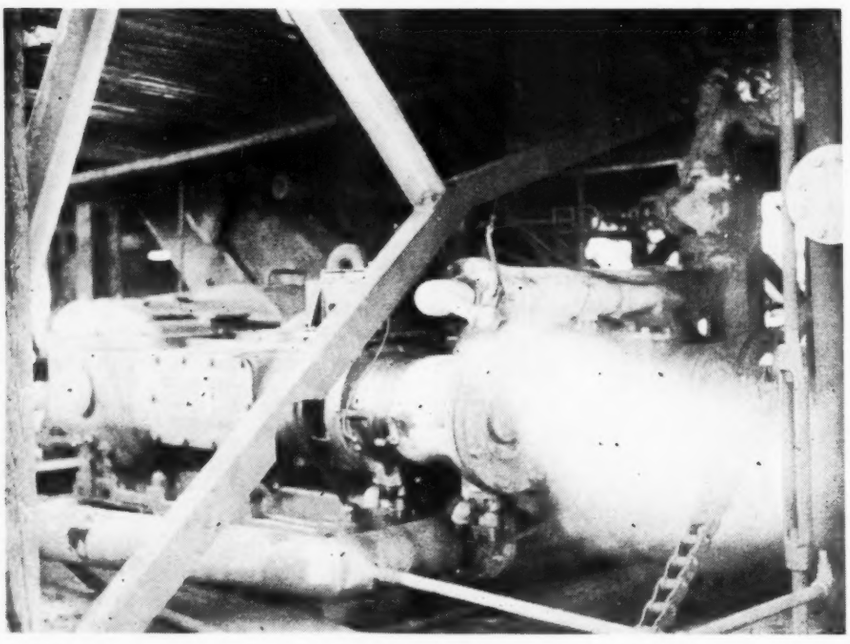
The drawworks was a 3-speed, 2-shaft-plus-cathead-shaft type, fully enclosed and driven by a 14-in. by 14-in. twin steam engine. A single hydromatic brake was used on each end, an arrangement that is believed to give better balance than the double-type placed at one end. The crown block contained six 48-in. sheaves, and the traveling block five. Sheaves were interchangeable between the crown and traveling blocks.

Of particular interest in drilling this well was the "step-down" method already mentioned and indicated in Fig. 1. A 12¼-in. bit was selected as the best size for the high rotating speed planned and the conditions expected in the greater portion of the drilling. Although this well was a wildcat, the formations to be penetrated were rather well anticipated and a 13⅜-in. surface string could have been used. To provide, however, for any contingency that might require a protective string, 16-in. surface pipe was run and cemented at a depth of 1512 ft.

A 12¼-in. hole was then drilled to 10,223 ft. at the rotating speeds mentioned. At that point, hole was reduced to 11¾ in. and the 5 9/16-in. drill pipe was replaced by 4½-in. At 11,500 ft., the hole was reduced to 11-in. Beginning at a depth of 12,380 ft. continuous coring was carried to a total depth of 12,985 ft. using 4½-in. drill pipe. The hole from 12,380 ft. to bottom was later reamed to 8⅝-in. diameter, after which a 7-in. water string was run and cemented at 12,787 ft.

By reducing the size of the hole after reaching 10,223 ft., it was believed that injury to the wall while running in and out of the hole would be reduced to a minimum. The shoulder of each reduced section shown in the sketch was subjected to destructive action for only a short time while making a round trip and the hole was thus kept in better condition. By maintaining the condition of the hole one string of casing, which would have been required as a protective string, was eliminated. It was also found that a saving in mud expense was obtained by this method of stepping-down the size of the hole.

Under certain conditions prevailing in this district it is believed that reduction of the size of hole by steps in this manner eliminates not only one string of casing and its cementing job but an extra cementing job also may be obviated. The water string itself can be cemented lower and on top of the sand, thus allowing the liner to be hung in the casing without a cementing job below the shoe of the water string.



Underfloor rotary drive consisting of a 12-in. by 12-in. twin steam engine. In the background is the enclosed chain drive to the rotary machine above

P 615.635.4
P 625.450.4

Method of Determining Whether Electrical Protection Should Be Applied to a Pipe Line or the Line Reconditioned[1]

By D. B. GOOD
Electrolysis Engineer, The Texas-Empire Pipe Line Company

ON the afternoon of April 25, 1939, in conjunction with the Oil World Exposition at Houston, Texas, the Mid-Continent Cathodic Protection Association sponsored a meeting devoted to cathodic protection of pipe lines. The chairman of the meeting was Walter F. Rogers, secretary of the association. Rogers opened the meeting with an outline of the aims and purposes of the association. His remarks follow:

The Mid-Continent Cathodic Protection Association was formed approximately one and one-half years ago as a result of popular demand for a forum at which those interested in this subject could discuss mutual problems. The advisability of such a forum is further manifest through the fact that installations of this type may involve pipe lines of other companies. When electrical drainage is placed on a section of pipe line the current flow will be along the paths of least resistance. If an outside company has a pipe line in the forced drainage area this line may carry part of the current. This results in protection of the pipe at the area of current pick-up and corrosion at the area of current loss. It is necessary, therefore, for the outside line to be bonded to the protected line in such a manner that corrosion of the outside line does not occur. It is to discuss problems of this type and to develop specifications for their correct handling that are among the aims of this organization. In addition the organization wishes to give wide publicity to the value of cathodic protection and this is best done through frequent programs at which papers are presented. It is for this reason that the present program is sponsored by the association.

THE subject of determining whether electrical protection should be applied to a pipe line or whether the line should be reconditioned, for discussion purposes, has been divided into two separate parts, classified as follows:

[1]Paper presented at Oil-World Exposition, Houston, Texas, April 25, 1939.

D. B. GOOD

entered employ of The Texas Pipe Line Company in July, 1933—Was transferred to The Texas-Empire Pipe Line Company, Tulsa, Oklahoma, January, 1934—Received B.S. degree in electrical engineering, Rice Institute, Houston, Texas, 1931—Is an associate member of American Institute of Electrical Engineers.

First, as to locations where leakage or deterioration of pipe by corrosion has already been experienced or evidenced.

Second, as to locations of pipe or metal wherein no actual pits or leaks have yet been noted but where their occurrence would be exceedingly expensive and difficult to repair, and where damages would likely be excessive.

The problem of existing lines where leaks or deterioration of pipe or metal by corrosion have already been experienced or evidenced, constitutes in general the most frequently occurring situation for consideration to determine whether a reconditioning program is in order or whether electrical means can or should be applied for keeping the pipe line in service. In this case we will assume, to begin with, that past records of leaks and maintenance costs for some several years, but preferably for the life to date of the pipe-line section or system under consideration, are available for analysis of frequency and location of pitting, and of cost. Possibly the line has reached a point when it is rapidly becoming unserviceable, in which case immediate attention is necessary to determine whether to recondition extensively, to lay a new line, or to try cathodic protection.

The electrolysis engineer then starts with the problem of applying electrical protection to this line to arrive at the cost of protecting it. This problem involves a study of the number and size of units needed, power costs, equipment needed, and savings over reconditioning, if such can be realized.

The problem is first approached with the thought that it will be necessary to recondition or apply protection to the entire length of line. This would be a case where general corrosion has been experienced over the entire length of the line. A preliminary test is first made at a point where the engineer thinks the first unit may be needed. In this locality, then, the position may be determined more exactly by taking soil resistivity measurements, considering the general terrain, and determining the point of lowest ground-bed resistance. The location of this ground bed must, of course, be reasonably close to the pipe line and to the power-supply line if rectifying sets are to be used. If windmills, gas engines, etc., are contemplated, the location is not quite so restricted, but in any case the most suitable location for lowest possible ground-bed resistance is of extreme importance.

The usual preliminary set-up for drainage is then established, using portable testing equipment and a temporary ground bed, which need not be large or extensive, depending mainly upon the test equipment available and on the trial drainage currents contemplated.

Several curves of potential to ground of the pipe for various currents are obtained and plotted, showing for each value of current the extent of protection either way from the test point and giving the answer to the first unknown quantity; that is, the amount of pipe, from this one station only, that can be fully protected by various currents. If we have picked the right site for Unit No. 1, and at which we may

assume there is an existing power source, we are ready to do some more calculating.

The voltage required on a permanently operating system for use in preliminary calculations and estimates, and for ordering equipment in some cases, may be obtained in one of several ways as follows:

(1) The test ground may be of a standard type, from which may be calculated the approximate resistance for a final installation, such data being obtained from past experience and calculations. That is, it may be known that on the usual type of ground used on final installations, the resistance is likely to be a certain percentage of that observed from the temporary test ground used.

(2) If no effort is made, from the temporary test ground, to determine the final ground resistance, this value can sometimes be approximated by the use of a megger and a four-bar method of measuring soil resistivities or by other reasonably accurate means. Then by calculating from formulas available or curves plotted from these formulas, the resistance of a ground bed of the size and design contemplated may be determined. The accuracy of this method will depend upon soil uniformity and care in testing.

(3) The third choice is to use the above means for obtaining preliminary figures for estimating expected size and cost of operation of a unit or units. Then if the project is justified and approved, a permanent ground bed may be established and another test made to obtain the actual total circuit resistance before specifying equipment. This is the preferable procedure.

It should, of course, be kept in mind that the ground-bed resistance may vary considerably over a period of time. Even with constant drainage currents, the potentials of pipe to ground vary appreciably in some localities with the seasons. These latter variations of potential are noted where stray-power currents are not involved. Proper consideration should, therefore, be given to these variables, calling upon past experiences to a great extent. In states or areas where the weather variations are considerable and where freezing or below-freezing weather is experienced, it is found that there is quite a variation in effective "spreads" or range of protection from cathodic units, varying with the seasons, other factors being constant. In the winter the ground resistance increases, making possible greater "spreads" than under summer operating conditions.

When using soil resistivities for the determination of probable ground resistances or rather, total circuit resistance, it should be remembered that aside from the actual ground resistance itself, there are several other parts constituting circuit resistance such as connected wires and pipe contact resistance; the latter comprises in most cases an appreciable percentage of the total, particularly in low-resistance soils. Also, some allowance should be made for expected increase in total circuit resistance with time, this being dependent upon design of ground bed, soil formation, rainfall, currents discharged from anode, etc.

It has been determined, then, from these preliminary tests, the amount of pipe that can be protected by a given current at a given voltage. The type of equipment can now be selected for converting a.c. into d.c. The overall efficiency of the rectifying equipment selected is already known. The a-c. power rate is known, and from this the average monthly power bill can be obtained. When wind-driven generators, gas engines, or other equipment for generating d-c. energy is used, the cost to operate such converters is also known.

The cost of reconditioning can now be calculated, or the cost of maintenance, as the case may be. Knowing from past records the prolonged service life that may be expected from a reconditioning program, the frequency of the need for such a job in a given number of years is known and the total costs may be set against the electrical protection figures in a comparative way. In cases where partial reconditioning is in order and has been carried on, the cost per year of such a program is also known and can be compared against cost of applying electrical protection. In any event each case must be considered as a distinct problem in determining the most economical procedure to follow.

It is well known that where more than one unit is required, as shown by the preliminary tests, the amount of pipe that can be fully protected per unit is raised considerably over that of one unit operation. An example involving three units shows that the average miles of pipe protected, on an individual basis, is 6.1; the average miles on simultaneous performances is 8.7, or an increase on fully-protected pipe, by addition of values less than 0.3 volt on connecting or overlapping ends, of about 40 percent. On multiple installations the total power consumption can usually be materially reduced under that of a single large unit to protect the same amount of pipe, comparative operating costs depending, however, on power rates, equipment, and installation costs.

If the section of line we are considering, therefore, requires multiple operation, and these units can be suitably situated, which it is not always possible to do, it is necessary to make simultaneous tests for determining the potential changes using multiple units and to calculate the costs of operation and installation against the reconditioning or maintenance costs for this set of conditions.

Another variation of the problem exists when only short lengths of line on the entire section are known "hot-spots". In such cases, the costs of electrical protection against reconditioning approach each other more closely. It may even pay to recondition short sections rather than to attempt cathodic protection where hot-spots are great distances apart, especially on poorly-coated lines requiring considerable expenditure of power for providing even limited protection.

The second part of this study concerns sections of pipe or metal wherein no actual pits or leaks have yet been noted but where their occurrence would be exceedingly expensive, if not impossible, to repair and where damages would likely be excessive. Under this category should be included river crossings, lakes, either natural or artificial, lines through towns or edges of cities, lines under pavement, tank bottoms, etc.

In some instances, surveys may show current losses to or in rivers in which case there is no question of the advisability of elimination of the loss. It is fairly difficult in some cases to effect this elimination merely by insulation, or perhaps the river water is contaminated and corrosive, so cathodic protection is adopted for a definite solution of the problem. When no current losses are noted, and when soil and water tests are negative as regards corrosion, there is still a very real possibility of having a leak in the river.

Thus, it is seen that in some cases, past records, data, etc., cannot be used as a basis for the justification of application of electrical protection; nevertheless, in many instances there is ample evidence that protective measures are fully warranted by the special conditions existing with respect to these pipe lines.

In conclusion, it is believed that the method of applying electrical protection for the mitigation of corrosion of underground structures should in all cases be considered prior to any extensive reconditioning program. Also, that at other points where leaks would be unusually difficult to repair or unusually costly in repair costs or property damage the prevention of these leaks by cathodic protection measures should be given careful consideration.

General Procedure in Manufacturing Natural Gasoline[1]

By DAVID E. FIELDS

Vice-President and Sales Manager, Tulsa Boiler and Machinery Company

IN manufacturing natural gasoline by the absorption method, the wet gas comes from the field under well pressure or under vacuum and first passes through an inlet scrubber where any crude oil carried in from the field separators is knocked-out. From the inlet scrubber the gas passes through the absorbers if under well pressure. If under vacuum, compressors are used to boost the gas through the absorbers. It enters under the bottom bubble tray and passes upward through the trays where the mineral seal or absorption oil absorbs the gasoline hydrocarbons in the wet gas and the dry gas then passes from the top of the absorber and into the residue scrubbers. In passing through the residue scrubbers any mineral seal oil carried-over in the dry gas from the absorbers is knocked-out and trapped-back into the oil system of the gasoline plant. The dry gas then leaves the residue scrubbers for repressuring, is sold as fuel to a pipe line, or is burned in a carbon black plant.

The rich oil that has absorbed the gasoline hydrocarbons leaves the bottom of the absorbers and passes to a set of heat exchangers where it is gradually heated to a temperature ranging from 260°F. to 310°F. or more, depending upon the boiler pressure at the plant. The rich oil leaves the heat exchangers and enters a vapor exchanger where it is further heated by the hot gasoline vapors coming from the top of the evaporator before they pass into the dephlegmator. From the vapor exchanger, the rich oil passes to the steam preheater where live steam further heats the rich oil before it enters the evaporator at the top tray. The rich oil then passes downward over and through the bubble trays in the evaporator and is reheated by two heating elements contained in the evaporator; one above the second bubble tray from the bottom and the other above the bottom tray. Into the bottom of the evaporator live steam is introduced to strip the rich oil of its gasoline content.

The hot lean oil is discharged from the bottom of the evaporator and enters the heat exchangers where its heat is transferred to the cold incoming rich oil from the absorbers. In the exchangers the lean oil is cooled to 120-130°F. before entering the lean-oil surge tank to be picked up and pumped through the lean-oil coolers and back to the absorbers where it again absorbs the gasoline hydrocarbons from the gas. This completes the oil cycle in the plant.

DAVID E. FIELDS

received a B.S. degree in mechanical engineering from University of Oklahoma in 1925—Joined the Tulsa Boiler and Machinery Company, Tulsa, Oklahoma, the same year and left in 1926 to join the Shell Petroleum Corporation organization in the construction division—Returned to staff of Tulsa Boiler and Machinery Company and now is vice-president and sales manager and has charge of the engineering and design of gasoline plant and refinery equipment—During the last year was president of the Natural Gasoline Supply Men's Association—Is a member of the Tulsa Club, Tulsa Engineer's Club, Technical Club of Oklahoma, Oklahoma Society of Professional Engineers, and Masons.

The gasoline vapors from the top of the evaporators are passed through the vapor exchanger before entering the dephlegmator under the bottom bubble tray. The vapors pass upward through the bubble trays in the dephlegmater and are taken out the top to enter gasoline-condensing coils. From there the gasoline goes into the make-tank prior to being stabilized and treated in preparation for storage. In the dephlegmator the vapors are refluxed with either water or gasoline to knock-down the heavier fractions and control, thereby, the end-point of the gasoline production.

A water trap is installed at the base of the dephlegmator and the condensed agitation-steam coming over from the evaporator is trapped-off and returned to the feedwater heater. An oil trap is provided in the base of the dephlegmator to eliminate the heavy ends of the gasoline and any oil that may be carried over from the evaporator. An ejector is used to return this trapped oil to the evaporator.

The raw gasoline production is fairly "wild" so that stabilization to lower vapor pressures is necessary before the gasoline may be marketed. The feed pump at the stabilizer pumps the gasoline from the make-tank through the gasoline heat exchangers and into the stabilizer column. Connected to the bottom of the stabilizer column is a reboiler, utilizing live steam through the tubes of its heating element to heat the gasoline. A reflux condenser is situated usually on top of the stabilizer for gravity reflux. In some installations, the reflux condenser is placed in the cooling tower and the reflux is pumped back to the top tray of the stabilizer to aid in fractionating the gasoline. The rate of reflux is controlled by a flow controller. The hot stable gasoline leaves the bottom of the stabilizer and passes through the gasoline heat exchangers in which its heat is transferred to the cold incoming raw gasoline. The stable gasoline then enters the final gasoline coolers in which it is cooled to within 5° of the cooling-water temperature. The light ends from the top of the stabilizer are used as a refrigerant or sold as liquefied gas.

Formerly these light ends were usually wasted or burned under boilers. In the last ten years liquefied gas has been adopted widely as fuel for farm lighting and gas engines and as charging stock in polymerization plants so that, today, few of these lighter ends are wasted.

Usually the lean-oil coolers, gasoline condensers, dephlegmator water coolers, stabilizer condensers and coolers are of the atmospheric type and are placed in the cooling tower. Some plants, however, employ the closed-type absorber if water must be conserved or other conditions indicate their use.

Some of the recent improvements in equipment for the manufacture of natural gasoline have resulted from an

[1]Title of paper presented at Panhandle Chapter Meeting, A.P.I., Pampa, Texas, April 11, 1939, which, because of its practical value, is presented herewith.

increased knowledge of the basic processes. For example, we know that the colder the lean oil is as it enters the absorber the greater will be the amount of gasoline hydrocarbons absorbed from the gas. Expressed another way, to absorb certain hydrocarbons less absorption oil will be required if its temperature is lowered. Using either atmospheric- or closed-type coolers the nearest approach to the cooling water temperature is usually 7°F. In order to obtain the cold absorption oil needed to take high percentages of butane from the gas most of the new plants are employing refrigeration to chill the lean-oil stream before it enters the absorber. This may be done in either of two ways. One method involves the use of a conventional absorber, usually with 20 bubble trays. The oil is chilled by an oil-chilling element that sets alongside the absorber. The oil passes through the tubes and the refrigerant, a propane-butane mixture in the liquid-phase under pressure, is around the tubes. This usually cools the oil to a temperature about 15°F. below the outlet temperature from the atmospheric oil-coolers in the cooling tower. The other method involving a different type absorber is used in new plant installations. Two oil-chillers are installed in the absorber; one above the third bubble tray, and one above the fifth bubble tray from the bottom. The oil circulates around the tubes within the shell of these oil-chilling elements and the refrigerant is vaporized by expansion in the tubes of the two chilling elements connected in series. A recompressor then compresses these vapors into liquid again, which enters a surge tank prior to return to the chilling elements, thus completing the cycle.

In most of the plants now operating on the Gulf Coast it has been found that the rich oil leaves the absorber at virtually the same temperature as the incoming lean oil to the absorber, which shows that the heat of absorption has been offset by the additional cooling involved in refrigerating the oil. This usually amounts to 15°F. or more, which represents a large saving in reduced oil circulation rates.

Another new feature in the modern gasoline plant is the use of the vapor exchanger. The rich oil after leaving the heat exchanger is heated 6 to 10°F., depending upon the amount of gasoline produced as it passes through the tubes of the vapor exchanger before entering the steam preheater. This heat is imparted to the oil by the vapors taken from the top of the evaporator and routed through the vapor exchanger before they enter the dephlegmator under the bottom tray. It is possible to use the vapor exchanger only on gasoline plants in which the evaporator and dephlegmator functions are conducted in two separate columns. On some plants a combined evaporator and dephlegmator is used in which the dephlegmator is above the evaporator as integral parts of one tower.

In equipment designed for processing corrosive gas, stainless-steel bubble caps are used in the absorber, evaporator, and dephlegmator. The downcomers and seals are usually made of pipe having $\frac{1}{16}$ in. heavier walls and $\frac{1}{8}$ in. is usually added to the thickness of the shell, heads, and bubble trays, than in comparable materials used for sweet gas. Manholes were formerly installed in the shells above each tray, but in modern practice manholes are provided only above the top bubble tray and below the bottom bubble tray. Manholes on all the trays enable a man to go through the bubble tower from top to bottom when inspection is necessary.

Another modern development is in the use of superheated exhaust steam in the base of the evaporator instead of saturated steam. Back-pressure is held on the steam exhausts of the turbines driving the oil pumps and the exhaust steam is passed through a superheater in which it is dried out and superheated and then introduced into the evaporator to serve as agitation steam. The oil level in the evaporator is controlled by using a float valve having a cam-operated block instead of the ordinary direct-connected liquid-level controller. The cam-operated block increases or decreases the pressure on the lean-oil surge tank. As the pressure on the surge tank is decreased, more lean-oil flows through the heat exchangers. When the cam-operated block type of controller is used the lean-oil is several degrees hotter as it leaves the base of the evaporator because no expansion is permitted. When the direct-connected controller is used the oil is subjected to some cooling as it passes through the balanced valve and the pressure is reduced as a consequence of this cooling.

Another new feature is the feedwater heater of the open-type that also incorporates the features of a water purifier and condenser. Direct contact between exhaust steam and make-up water is obtained in the lower part of the feedwater heater by a tray and deflector plates. Atmospheric condensation takes place in the upper part of the heater in the nest of tubes exposed to the air. In the top there is a mist extractor to prevent carryover of the liquid. A balanced valve on the make-up water line with an inside float maintains a constant water level in the feedwater heater and makes the heater virtually automatic in operation. No pressure is held on the feedwater heater other than atmospheric. The water from the water-trap on the dephlegmator is introduced into the heater near the bottom. All exhaust steam from the various pumps and turbines not required in the evaporator is introduced through a large opening near the top of the bottom compartment. The temperature in the bottom compartment is approximately 190°F. The feedwater pump takes suction from the bottom of the heater and discharges into a mixing tank, which is under approximately 175-lb. pressure when the boilers are operating at 200-lb. pressure.

The condensate both from the heating elements of the evaporator and from the preheater is also introduced into the mixing tank. The pressure on the heating elements is sufficient to force the condensate into the tank so that no pump is required. The resultant temperature after mixing the two water streams is approximately 275°F. A boiler-feed pump takes suction from the mixing tank and discharges the feedwater into the boilers. The steam saving on this hook-up is obvious. The combined condensate from the evaporator heating elements and preheater is approximately one-half of the boiler feedwater requirements of the plant. This water is at a temperature just a few degrees below the boiler temperature and relatively little heat is required to convert it back into steam.

The compression-type plant is used successfully in the manufacture of natural gasoline only when extremely rich gas is available for processing. In this method the natural gas is gathered from the field and is compressed usually to 275-300 lb. per sq. in. The compressed gas passes through coolers to condense the gasoline content and into accumulator tanks. Residue gas from the top of these tanks is used as plant fuel.

One of the newest compression-type plants uses gas direct from the wells at pressure as high as 1200 lb. per sq. in. The gas is processed through a series of heat exchangers or chillers in which temperatures as low as 30° below zero are obtained using liquefied gas as a refrigerant. The condensate is then collected in an accumulator tank, after which it is stabilized as in the absorption process. The gas is then recompressed to pressures high enough to permit its introduction into the gas-producing sand. The use of this system is confined to those areas in which condensate or distillate recovery is the sole production and the return of gas to the sand is a necessary part of efficient operation.

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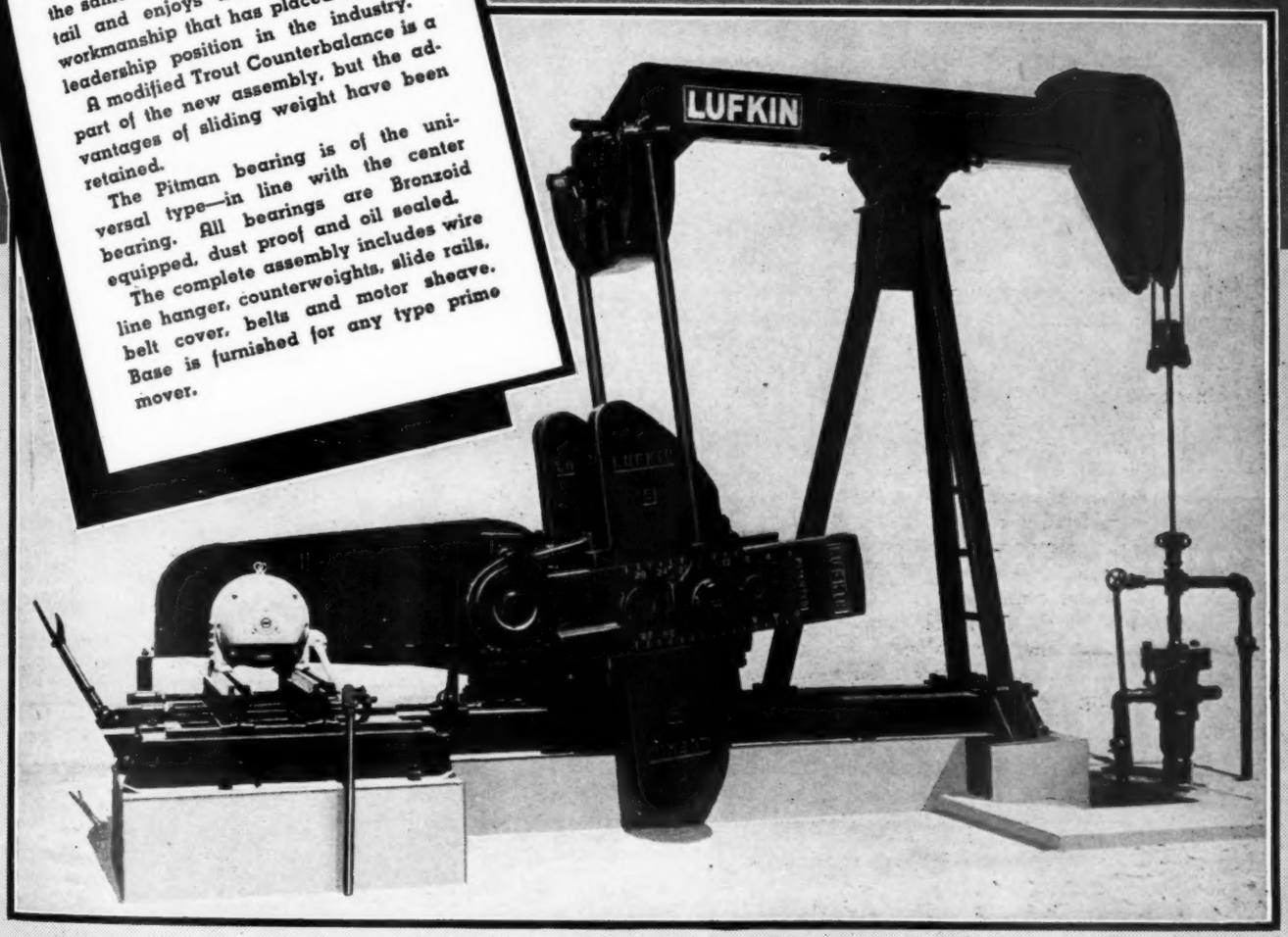

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Graphical Method Determines Efficiency of Gasoline Trunk Lines

Periodic calculation based on pressure and volume of throughput permits expression of load-carrying efficiency in "percent normal"

By FRANK H. LOVE
Managing Editor

OPERATING experience acquired during the last ten years has shown that the capability of a gasoline pipe line to carry the tonnage for which it was initially designed is dependent upon maintaining the dimensionless number known as "roughness factor" at the highest possible value.

The growth of internal tubercles together with scaly deposits combine to produce such a high degree of skin friction between the pipe wall and gasoline that line throughput capacities can quickly depreciate as much as 9 or 10 percent, even though the dynamic pressure remains constant. Several theories have been advanced to account for the continuous production of the corrosive matter. The generally accepted hypothesis is that water in combination with excess oxygen is the cause. Inhibitors compounded from several elements have been injected into the gasoline stream to absorb the excess oxygen and thus arrest or eliminate what is considered one of the primary causes of the corrosion. The statement that these inhibitors have been even partly successful cannot at present be substantiated by the results obtained.

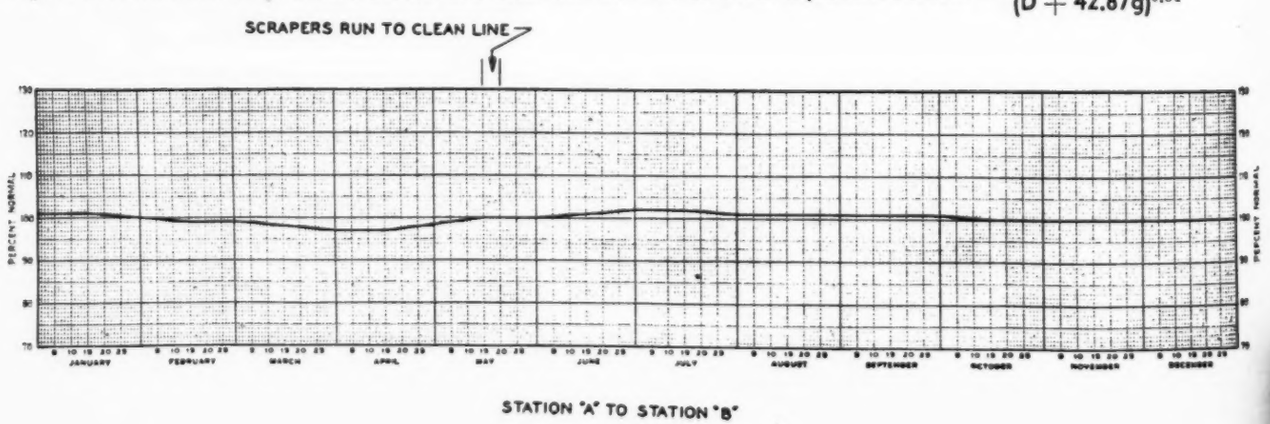
Gasoline pipe lines are analogous to gravel roads, inasmuch as after a definite operating period their roughness factor, generally called "C" value, causes such resistance to flow that the velocity of the stream, comparable to an automobile's road speed, must be decreased if the power that produces this velocity is to remain within the bounds of safety. The traffic velocity over the road, however, can be appreciably increased by constant blading and scraping, a condition that is simulated in the pipe line when scrapers are run to smooth-out the corrugated surfaces and thus reduce the resistance to flow. It is obvious that reduced resistance per unit of length should result in lower pressures throughout an entire section without reducing the volumes pumped. As nearly all gasoline pipe-line velocities are in the turbulent range, the discussion that follows is based solely on flow of this character.

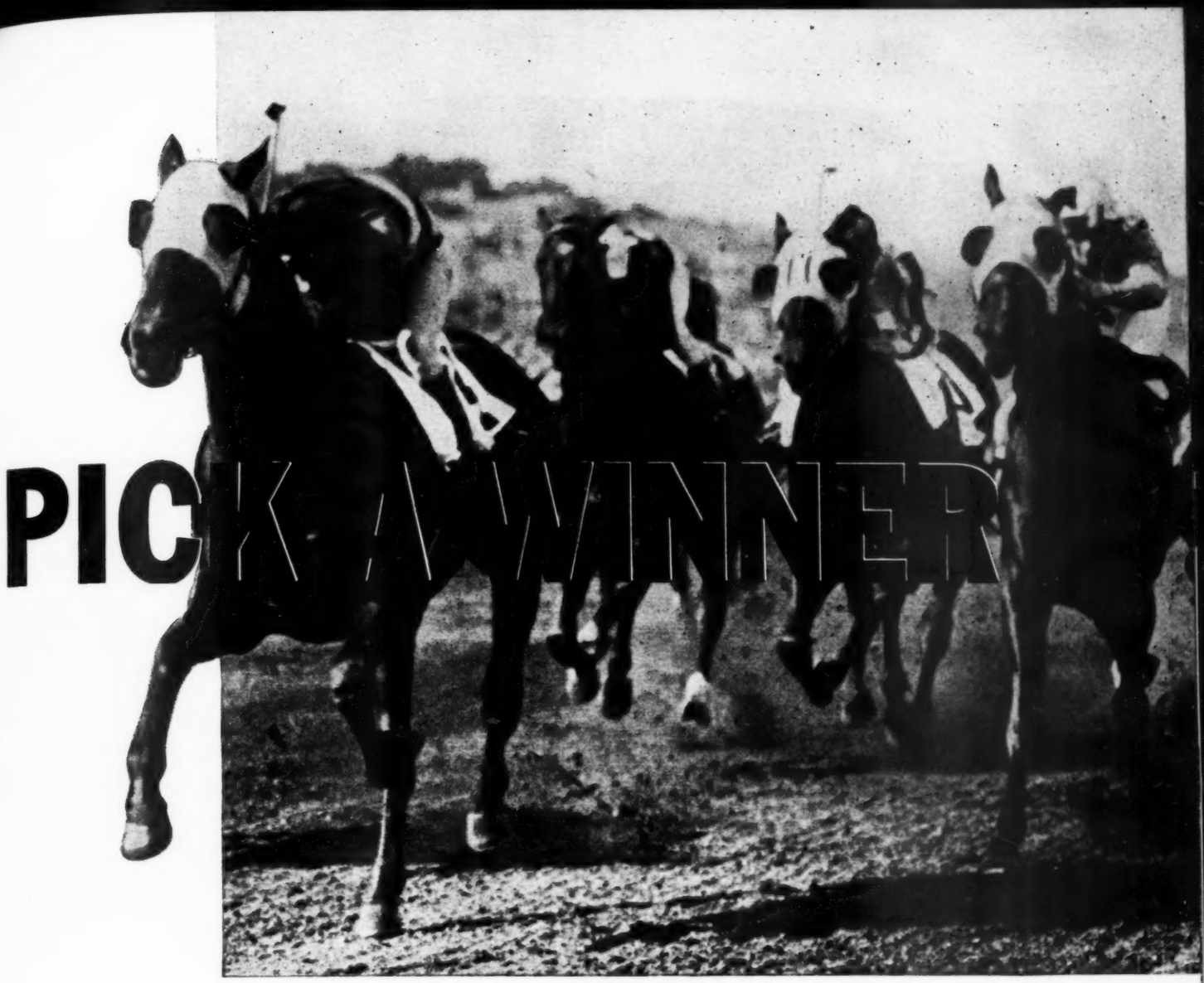
To maintain a careful observation of the efficiency of gasoline lines, some system of recording their daily performance is necessary from which it should be possible to determine the effects of time and tonnage throughput on the ability of a line to carry its quota without excessive power increases. By introducing the roughness factor, or "C" value, as set up in the Williams-Hazen formula, to provide a figure from which the relative internal condition of all lines can be gauged, it is possible to plot a curve accurately showing the performance of these lines by sections over extended periods of time. By carefully analyzing the traverse of this curve and watching its trend with reference to a predetermined datum, it is possible to detect the section that is causing the restriction between transmitting and receiving extremities. It is obvious, of course, when a section discloses itself as responsible for a choke in a long-line traverse, that scrapers should be run a sufficient number of times to raise the "C" value and consequent efficiency to a figure equal to or greater than the normal datum rating for the section.

An inspection of the formula shows that with all other conditions constant, any percentage changes in the value of "C" causes the same percentage change in the throughput volume; for example, a 10 percent increase in "C" results in a 10 percent increase in the throughput quantity. Specific gravity changes have a comparatively small effect on "C" and pipe-diameter variations tend to increase or decrease its value in inverse ratio.

Contrary to rational theory, these observations have shown that "C" decreases with increase in line diameters, or vice versa. Empirically speaking, the following values in clean lines have

Fig. 1. Percent normal by months before and after the line was cleaned. Equation: Percent $= \frac{3.054\, g^{0.54}\, Q}{(D + 42.87g)^{0.54}}$





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Take those close-shave workover jobs, for example . . . ticklish business, so the cement has to be right, For one thing, the cement is in direct contact with the drilling fluid; that calls for heavy slurries that minimize contamination, yet pump easily so as to penetrate the formation thoroughly and uniformly.

The cement also has to be slow-setting, to allow plenty of time to complete the job; yet, once in place, it has to gain strength rapidly, in order to offset agitation.

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Pick a winner: Use 'Starcor'* also for deep wells, high temperatures, extra sulphate resistance . . . 'Incor'* in wells of moderate depth . . . Lone Star for work above-ground. Portland cements, all—each the quality standard in its own field.

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been accepted as indicating maximum operating pipe-line efficiency:

Line Size	"C"
4 in.	140
6 in.	135
8 in.	130

No satisfactory theoretical discussion of the loss of head in pipe flow can be made. In smooth straight pipe the eddying motion of the gasoline when flowing faster than the critical velocity is so complicated that loss of head cannot be expressed by any theoretical formula. When this turbulence in the gasoline flow is further influenced by the roughness of the interior of the pipe, it seems hopeless to expect that the loss of head may be reduced to a mathematical expression based on theory alone; consequently, the variable "C" may assume any value (within certain limits, of course) to satisfy the throughput conditions prevailing. The incrustation on the interior surface of the pipe, aside from decreasing the average diameter, restricts free movement of the eddy whirls characteristic of flow above the critical velocity and thus creates a turbulence that greatly increases the internal fluid friction and consequent power requirements.

Referring again to the Williams-Hazen formula for gasoline flow, it is desirable that the values determined for "C" be reduced to their simplest terms. All constants, including lineal distances and elevation differences, should be written into it and each section will, necessarily, have an equation of its own.

Graphical Method

A complete example developed for a line section between successive stations shows the adaptation of the method. An inspection of the section as a whole shows that its capacity (based on a "C" of 130 and a discharge pressure not exceeding 850 lb. per sq. in. through approximately 26.5 mi. of 8-in. pipe) is 1485 bbl. per hr. or 36,640 bbl. per day. These figures are accepted as the normal capacity and pressure conditions and are considered as determining factors of the datum base that is used.

Of the two methods available for plotting the data, incorporating either the specific values of "C" set forth as ordinates in one or the percent values of "C" as ordinates in the other, against time plotted as abscissas in either method, the percent method is depicted in the following arrangement:

The Williams-Hazen formula written for gasoline flow is:

$$P = \left(\frac{65 g^{0.54} Q}{C d^{2.63}}\right)^{1.85} \quad . . \quad (1)$$

wherein

P = friction loss, lb. per sq. in. per 1000 ft.
g = specific gravity of gasoline
Q = quantity, bbl. per hr.
C = roughness factor
d = inside diameter of pipe, in.

Letting L = length of line in thousands of ft. and
P_f = total pressure drop due to friction, then

$$P_f = \left(\frac{65 g^{0.54} Q L^{0.54}}{C d^{2.63}}\right)^{1.85} \quad . . . . . (2)$$

The "hill" pressure will be

$$P_h = \frac{\frac{Z_2 - Z_1}{2.31}}{g} = (Z_2 - Z_1)\ 0.433 g \quad . . . . . (3)$$

wherein

P_h = hill pressure, lb. per sq. in.
Z_2 = elevation of downstream station, ft.
Z_1 = elevation of upstream station, ft.
g = specific gravity of gasoline

Letting D = discharge pressure in lb. per sq. in., then

$$D = (P_f + P_h) \quad . . . . . (4)$$

Substituting (2) and (3) and rewriting,

$$D = \frac{65^{1.85} g\ Q^{1.85}\ L}{C^{1.85}\ d^{4.87}} + [(Z_2 - Z_3)\ 0.433 g] \quad . . . . . (5)$$

Solving for C

$$D = \frac{65^{1.85} g\ Q^{1.85}\ L + [(Z_2 - Z_1)\ 0.433 g]\ C^{1.85}\ d^{4.87}}{C^{1.85}\ d^{4.87}}$$

$$C^{1.85} = \frac{65^{1.85} g\ Q^{1.85} L}{d^{4.87}\left\{ D - [(Z_2 - Z_1)\ 0.433 g] \right\}}$$

$$C = \frac{65 g^{0.54} Q\, L^{0.54}}{d^{2.63}\left\{D - [(Z_2 - Z_1)\ 0.433 g]\right\}^{0.54}} \quad . . . . . (6)$$

Rearranging (6)

$$Q = \frac{C d^{2.63}\left\{D - [(Z_2 - Z_1)\ 0.433 g]\right\}^{0.54}}{65\ g^{0.54}\ L^{0.54}} \quad . . . . . (7)$$

Showing the application of the formula between stations "A" and "B", in which

Distance from A to B = L = 139.728 (thousands of ft.),
elevation at A = Z_1 = 820 ft.,
elevation at B = Z_2 = 721 ft.,
and d = 7.981 in.
Then,

$$C = \frac{65 g^{0.54} Q\ 139.728^{0.54}}{7.981^{2.63}\left\{D - [(Z_2 - Z_1)\ 0.433 g]\right\}^{0.54}}$$

$$= \frac{65\ g^{0.54} Q\ 14.403}{235.73\left\{D - [(721 - 820)\ 0.433 g]\right\}^{0.54}}$$

$$= \frac{3.97\ g^{0.54} Q}{[D + 42.87 g]^{0.54}} \quad . . . . . (8)$$

Using "C" × 130 for 8-in. nominal inside diameter

$$\% = \frac{3.97 g^{0.54} Q}{130\ (D + 42.87 g)^{0.54}} \times 100$$

$$= \frac{3.054 g^{0.54} Q}{(D + 42.87 g)^{0.54}} = \text{equation for section A to B} \quad . . . . . (9)$$

If Q = 1500 bbl. per hr.,
D = 833.2, and g = 0.74.
Then the section percent normal

$$= \frac{3.054 g^{0.54} \times 1500}{(833.2 + 31.72)^{0.54}}$$

$$= \frac{3.054 \times 0.85 \times 1500}{864.92^{0.54}}$$

$$= \frac{3.054 \times 0.85 \times 1500}{38.546}$$

= 101.02 percent.

The comprehensive and reliable data graphically depicted provides an instantaneous visualization of line conditions for extended time periods. It can be used to forecast accurately line-cleaning operations considerably in advance of the time when such work is necessary, and to show the effect of such line-cleaning on volumes and pressures.

Fig. 1 plotted for the year 1937 shows the percent normal by months, before and after the line was cleaned.

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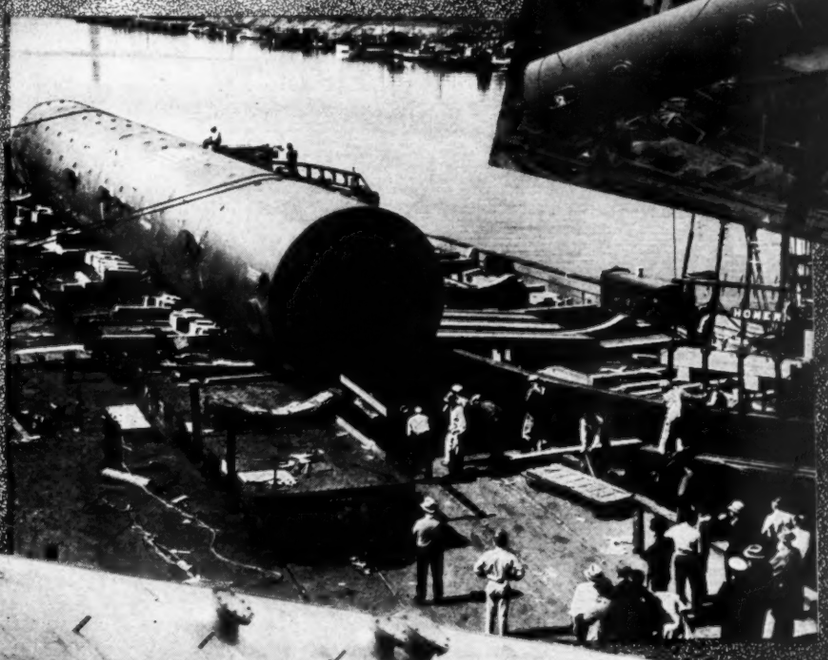
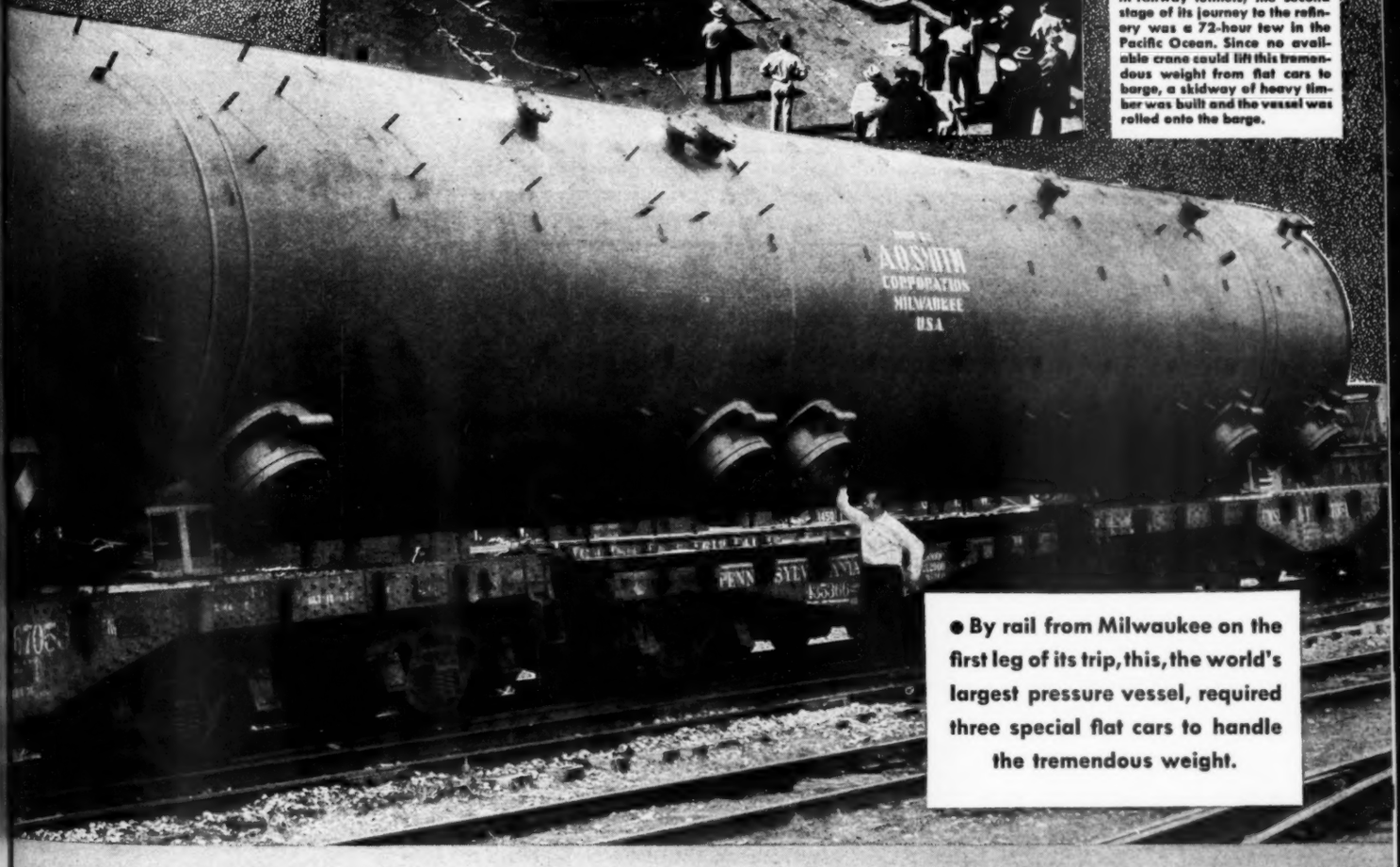
SMITH PRESSURE VESSELS



● Erecting the 150-ton pressure vessel, which is nearly 93 feet long, at the Oleum, California refinery of Union Oil Company. This job required engineering skill and some of the largest heavy-duty rigging ever used.

● Too long to negotiate curves in railway tunnels, the second stage of its journey to the refinery was a 72-hour tow in the Pacific Ocean. Since no available crane could lift this tremendous weight from flat cars to barge, a skidway of heavy timber was built and the vessel was rolled onto the barge.



● By rail from Milwaukee on the first leg of its trip, this, the world's largest pressure vessel, required three special flat cars to handle the tremendous weight.

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Thermal Dehydration of Ethane to Ethylene*

Pyrolysis of ethane should be performed in two stages—apparatus of intermittent action of ceramic packing is unsuitable

By L. POTOLOVSKII and A. ATAL 'YAN

Azerbaidzhan Petroleum Research Institute, Baku, Russia

ABSTRACT

Heating ethane at 675-850°C. for 0.3-0.6 sec. results in formation of ethylene, methane, hydrogen, and hydrocarbons higher than butane-butylene. At higher temperature, acetylene is also formed and at 875°C. its amount reaches 3-3.5 percent by weight. The highest yield of ethylene, 57.12 percent, was obtained at 850° and 0.3 sec. With a rise from 750° to 850°C., the amounts of hydrogen and methane also rise, and that of the latter reaches 10-12 percent, the total decomposition of ethane reaching 80-85 percent. At a temperature greater than 850°C., the yield of methane increases rather rapidly, as do the yields of higher hydrocarbons, acetylene and hydrogen. Useful decomposition of ethane (the amount decomposing directly to ethylene) is greatest at 675-725°C., at which temperature it is 93-87.5 percent. A single pyrolysis at 875-900°C. for about 0.05 sec. decomposes 85 percent of ethane, 79 percent decomposing directly to ethylene, the yield of which amounts to 62 percent by weight. At 700-750°C. the greatest yield of ethylene obtainable in a 2.9-7.0 sec. contact is 40-45 percent. In this case, 50-60 percent ethane decomposes, of which 75-77 percent enters into formation of ethylene, and it is suggested that the residual ethane can be economically recovered and subjected to a second pyrolysis. A longer duration of the reaction, 9-13 sec., reduces the amount of ethylene to 42 percent and increases that of methane from 7.5 to 15 percent effecting also a higher decomposition of ethane, to 66-70 percent. Presence in the initial ethane of 5-8 percent ethylene has no detrimental effect. Introduction of about 0.2 cc. water per liter of ethane to reduce the partial pressure of ethane in the reaction zone in an effort to increase the total yield of ethylene showed no advantage. The material of which the reaction chamber is fabricated has no effect upon decomposition of ethane.

GASES from pyrolysis and cracking of oil as well as natural gases from some oil fields contain considerable amounts of ethane. For instance, gas produced by pyrolysis of oil products contains 9-10 percent (by weight) ethane, and fractionation of the gas can produce a gas containing 95-100 percent ethane. Gases from liquid-phase cracking contain 12-15 percent (by weight) ethane. Conversion of ethane to ethylene is the most suitable synthesis of ethane at the present time. In general, the mechanism of decomposition of ethane is known, but the conditions of dehydrogenation of ethane for the production of the highest yields of ethylene have not yet been clarified.

[A review of research on thermal decomposition of gaseous paraffins is given with references to the work of Berthelot[1], Bone and Coward[2], Paneth and Hofeclitz[3], Meinert[4], Rice[5], Frey and Smith[6], Dintses and Zherko[24], Piotrowski and Winkler[7], and Paul and Marek[22]. In most cases the workers on the subject reached a conclusion that in cracking of ethane at temperatures to 700°C. during short reaction periods, the ethane is decomposed almost quantitatively into ethylene and hydrogen; and that the velocity of its decomposition follows the laws of unimolecular reactions.

In the present study, ethane was pyrolyzed and the resulting gas analyzed by fractionation in a Podbielniak apparatus and the unsaturated components were determined with sulphuric acid. Some components of the gas were determined by absorption; for instance, acetylene was absorbed by alkaline mercury cyanide, hydrogen by palladium black or by combustion over cupric oxide, divinyl was qualitatively determined by bromination. The apparatus set-up is shown in Fig. 1. The quartz reaction tube was 60 cm. long, but the volume of the reaction zone was not precisely determined. A palladium-rhodium thermocouple was used for measuring the temperature. The pure ethane used in most cases was prepared by removing the ethylene (3-7 percent) from the ethane fraction obtained by low-temperature fractionation of the cracked gas produced in Baku at the Azerbaïdzhan Synthetic Rubber Plant.]

Experimental Data

The thermal decomposition of ethane was studied at 675-900°C. and reaction periods from 0.01 to 13 sec. No experiments were conducted in which ethane was kept in the reaction zone for longer periods of time because this increases secondary reactions, reducing the yield of ethylene.

The results of the first series of experiments are given in Tables 1 and 2 and Figs. 2 and 3. These data show that the basic products of decomposition of ethane, in addition to ethylene, are methane and hydrogen and also hydrocarbons of higher molecular weight than butane, which are termed "higher hydrocarbons." The amount of butane and butylene as well as propane and propylene are insignificant. The presence of small amounts of propane, propylene, butane, and butylene in the products of decomposition of ethane can be explained by synthesis from radicals

$$\cdot CH_3,\ :CH_2,\ \vdots CH$$

formed in decomposition of ethane:

$$2{:}CH_3 + {:}CH_2 \longrightarrow CH_3 \cdot CH_2 \cdot CH_3$$

*NEFTYANOE KHOZYAISTVO *(The Petroleum Industry)* Vol. 19, No. 4, pages 40-50, April, 1938. Translated by Foreign Literature Service, Process Management Company.

This translation has been submitted by the Petroleum Division of the American Chemical Society. The Petroleum Division, however, assumes no responsibility for the facts and opinions presented, nor does it necessarily endorse statements made therein.

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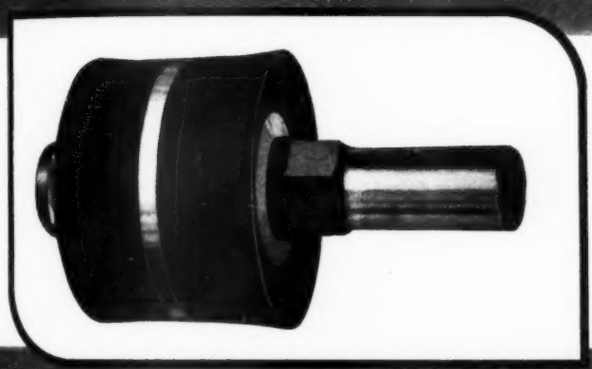

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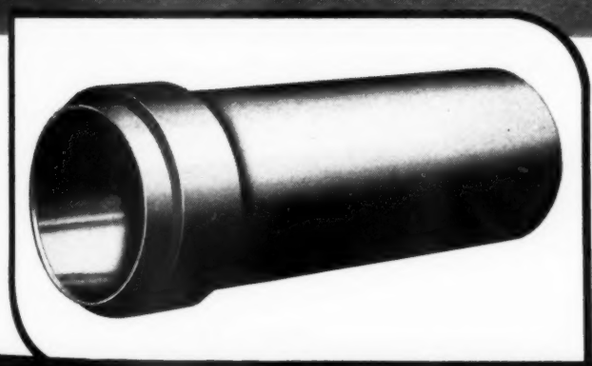

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Fig. 1. The laboratory set-up for dehydrogenation of ethane to ethylene. 1, 10—gasometers; 2—calcium chloride; 3, 9—manometers; 4—flowmeter; 5—electrical furnace; 6—reaction tube; 7—thermocouple; 8—millivoltmeter

$$\cdot CH_3 + :CH_2 + {:}CH \rightarrow CH_3 \cdot CH{:}CH_2$$

$$2 \cdot CH_3 + 2{:}CH_2 \rightarrow CH_3 \cdot CH_2 \cdot CH_2 \cdot CH_3$$

$$\cdot CH_3 + 2{:}CH_2 + {:}CH \rightarrow CH_3 \cdot CH_2 \cdot CH{:}CH_2$$

Propane is formed in larger quantities than propylene. At higher temperatures acetylene is formed, the amount of which increases with the rise of the temperature of pyrolysis, reaching 3-3.5 percent by weight at 875°C. Divinyl was also qualitatively detected in these experiments.

Formation of large amounts of methane in these experiments as well as of high-molecular paraffins and olefins makes it impossible to assume a simple dehydrogenation of ethane to ethylene according to the equation:

$$C_2H_6 \rightarrow C_2H_4 + H_2$$

Tables 1 and 2 as well as Figs. 2 and 3 indicate that a decline in the temperature of pyrolysis from 850° to 725-750°C. makes it possible to direct the decomposition of ethane predominantly toward dehydrogenation to ethylene. The yield of ethylene, however, is greatly reduced thereby, reaching 20-40 percent.

The highest yield of ethylene is 55-58 percent. This was obtained in a single pyrolysis of ethane at 825-850°C. At higher temperature the amount of ethylene obtained is reduced. A rise in the temperature from 750 to 850°C. produces simultaneously an increase in the amount of ethylene produced and an increase in the amount of methane formed, reaching 10-12 percent; an increased formation of hydrogen is also observed in this case. The total decomposition of the initial ethane at these temperatures is 80-85 percent.

Methane is found in the products of decomposition of ethane at 675°C. and its amount is gradually increased with rise in the temperature to 775°C. At a greater temperature the curve for

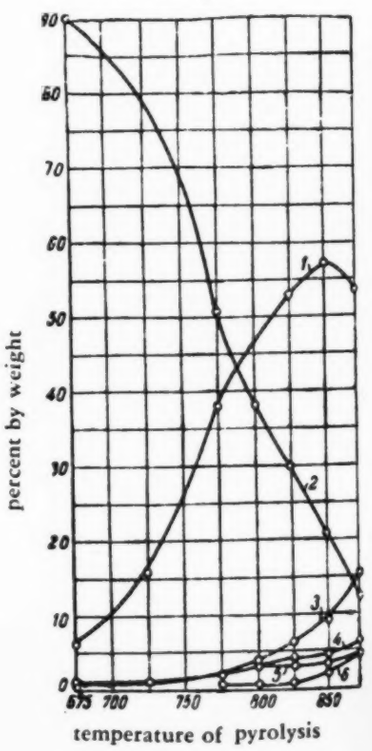
TABLE 1

Tempature of the pyrolysis, °C	675		725		775		800		825		850		875	
Time of exposure of the gas in the reaction zone, sec.	0.33		0.37		0.35		0.33		0.31		0.30		0.23	
Increase in volume of the initial gas	1.07		1.18		1.41		1.53		1.65		1.73		1.95	
Fractional analysis of the gas by the method of Podbielniak:	% by vol.	% by wt.	% by vol.	% by wt.	% by vol.	% by wt.	% by vol.	% by wt.	% by vol.	% by wt.	% by vol.	% by wt.	% by vol.	% by wt.
Methane	0.83	0.45	2.10	1.29	3.60	2.68	5.50	4.39	7.20	6.25	9.36	8.52	14.78	15.50
Ethylene	6.70	6.48	14.80	16.12	29.16	38.28	33.56	47.27	34.51	52.86	35.55	57.12	29.35	54.28
Ethane	86.26	90.52	67.21	79.24	35.93	51.06	24.99	38.14	18.54	29.94	12.22	21.25	6.35	12.72
Propylene	0.04	0.05	0.03	0.05	0.17	0.34	0.19	0.41	0.23	0.54	0.21	0.57	0.64	1.82
Propane	0.46	0.71	0.46	0.80	0.79	1.66	0.83	1.88	0.46	1.13	0.45	1.16		
Butylene + Butane	0.10	0.20	none	none	0.19	0.52	0.31	0.90	0.22	0.69	0.26	0.86	0.30	1.14
Higher hydrocarbons	0.41	1.23	0.40	1.32	0.56	2.20	0.70	3.06	0.74	3.56	0.75	3.72	0.85	4.86
Hydrogen	5.20	0.36	15.00	1.18	29.20	2.76	33.52	3.41	37.50	4.15	40.00	4.63	45.73	6.10
Acetylene	none	none	none	none	0.40	0.50	0.40	0.54	0.60	0.88	1.20	2.17	2.00	3.58
Specific gravity of the gas, calculated	1.0004		0.8910		0.7390		0.6882		0.6334		0.6039		0.5246	
Specific gravity of the gas by pycnometer			0.8920		0.7359		0.6769		0.6424		0.5936		0.5251	
Percent of useful decomposition of ethane to ethylene	93.1		84.3		83.3		83.1		82.0		77.9		65.3	

TABLE 2

Temperature of pyrolysis, °C	725		775		825		850		875	
Time of exposure of the gas in the reaction zone, sec.	0.62		0.60		0.60		0.56		0.55	
Increase in volume of the initial gas	1.30		1.45		1.68		1.80		1.98	
Fractional analysis of the gas by the method of Podbielniak:	% by vol.	% by wt.	% by vol.	% by wt.	% by vol.	% by wt.	% by vol.	% by wt.	% by vol.	% by wt.
Methane	2.50	1.72	4.00	3.00	8.56	7.67	12.66	12.09	16.28	17.10
Ethylene	24.19	29.33	29.40	38.94	33.08	52.22	34.61	58.35	27.26	50.52
Ethane	47.97	63.04	34.31	49.20	16.11	27.54	8.81	16.07	6.89	13.82
Propylene	0.12	0.22	0.20	0.42	0.67	1.88	0.33	0.86	0.47	1.34
Propane	0.42	0.78	0.28	0.57	0.35	1.63	0.64	1.73	0.76	2.26
Butylene + Butane	none	none	0.27 + 0.29	0.73 + 0.81	0.17	0.55	0.09	0.31	0.10 + 0.07	0.39 + 0.27
Higher hydrocarbons	0.75	2.81	0.72	2.94	0.60	1.93	0.64	3.34	0.93	5.34
Hydrogen	24.05	2.10	30.13	2.88	39.06	4.44	40.82	4.96	45.64	6.10
Acetylene	none	none	0.40	0.51	1.40	2.14	1.40	2.29	1.60	2.86
Specific gravity of the gas, calculated	0.7998		0.7325		0.6145		0.5755		0.5235	
Specific gravity of the gas by pycnometer	0.7886		0.7471		0.5983		0.5738		0.5198	
Percent of useful decomposition of ethane to ethylene	83.5		84.8		76.2		74.0		62.5	

Fig. 2. Dehydrogenation of ethane to ethylene in a contact period of approximately 0.3 sec. 1—ethylene; 2—ethane; 3—methane; 4—hydrogen; 5—higher hydrocarbons; 6—acetylene



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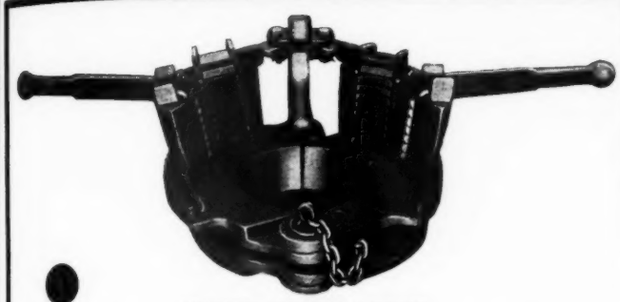

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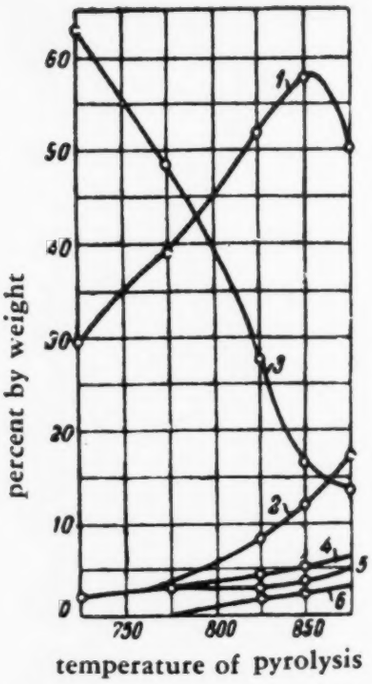

Fig. 3. Dehydrogenation of ethane to ethylene in contact periods of approximately 0.6 sec. 1—ethylene; 2—methane; 3—ethane; 4—hydrogen; 5—higher hydrocarbons; 6—acetylene

methane becomes steep, especially above 850°C., indicating considerable increase in the simultaneous formation of the higher hydrocarbons, acetylene and hydrogen. The amount of ethane in the reaction products is sharply reduced to 12 percent as the temperature increases. The results obtained in decomposition of ethane at the same temperatures and reaction periods of 0.3-0.6 sec. are very similar.

A calculation of the amount of usefully decomposed ethane (amount of ethane decomposed mainly to ethylene) based on the data of Table 1 and compared to the total amount of decomposed ethane shows that in this respect the lowest temperatures, 675-725°C., are most effective, producing 93-87.5 percent useful decomposition. At higher temperatures, 850-875°C., ethane is decomposed to ethylene only to the extent of 78.65 percent; the decomposition of ethane tends to form larger quantities of methane and hydrocarbons of higher molecular weight. From this a conclusion can be drawn that the greatest amount of ethylene in a single pyrolysis of ethane with short-reaction periods is best carried out at 800-850°C.

If it is desired to produce a higher yield of ethylene from a given amount of ethane, it is necessary to work at lower temperatures, about 700-750°C. In this case, however, ethane must be subjected to repeated pyrolysis and it must be separated from the products of pyrolysis after each cycle.

Reducing the duration of the reaction 10 times, i.e., at a reaction period of 0.05-0.06 sec., the most favorable results of dehydrogenation of ethane to ethylene in a single pyrolysis of ethane were obtained. The yield of ethylene at 875°C. reaches in this case 58 percent (by weight); only 4 percent methane and 2 percent acetylene are formed, the initial ethane being decomposed to 76 percent as shown by Table 3 and Fig. 4. A rise in the temperature to 900°C. increases the amount of ethylene to 62 percent, that of ethane to 7 percent, and that of acetylene to 4 percent. The initial ethane is decomposed in this reaction to 85.0 percent.

Thus, it is evident that the most favorable results of dehydrogenation of ethane in a single pass through the reaction zone are obtained at the highest temperatures, 875-900°C., and a short reaction period. The useful decomposition of ethane to ethylene under these conditions amounts to 79 percent.

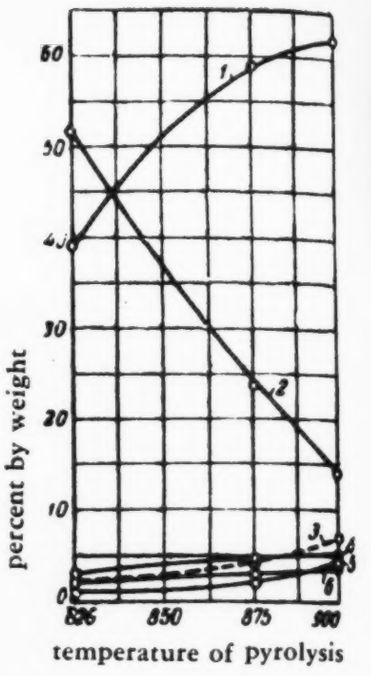

Fig. 4. Dehydrogenation of ethane to ethylene in a contact period of 0.05 sec. 1—ethylene; 2—ethane; 3—methane; 4—hydrogen; 5—acetylene; 6—higher hydrocarbons

As mentioned, the initial material consisted of ethane, carefully purified of admixtures of ethylene. In separation of cracked gases at low temperature, however, it is more economical to isolate ethane by using a small admixture of ethylene and from this point of view experiments with a gas of this composition are of great practical interest. Results of a series of experiments on decomposition of ethane containing admixture of ethylene are given in Table 4 and Fig. 5. A comparison of the curves of Figs. 2, 3, and 5 shows that the content of ethylene in the gas after pyrolysis of ethane containing no ethylene is almost equal to that obtained from the gas containing 5-7 percent ethylene. The amount of methane is lower in the case of ethane containing ethylene. For instance, at 875°C., it is 10 percent, whereas in the case of pure ethylene it is 15 percent. Consequently, it is not necessary to isolate 100 percent ethane for pyrolysis and more favorable re-

TABLE 3

Temperature of pyrolysis, °C	825		875		900	
Time of exposure of the gas in the reaction zone, sec.	0.058		0.052		0.048	
Increase in volume of the initial gas	1.34		1.52		1.87	
Fractional analysis of the gas by the method of Podbielniak:	% by vol.	% by wt.	% by vol.	% by wt.	% by vol.	% by wt.
Methane	2.76	2.07	4.48	3.98	7.25	7.12
Ethylene	29.25	38.81	37.69	59.11	35.82	61.62
Ethane	36.03	51.75	13.94	23.68	7.77	14.14
Propylene	0.11	0.23	0.36	0.87	0.42	1.11
Propane	0.31	0.63	0.92	2.30	0.63	1.74
Butylene	0.03	0.08	0.10	0.32	0.26	0.92
Butane						
Higher hydrocarbons	0.56	2.29	0.63	3.05	0.65	3.46
Hydrogen	29.95	2.86	40.48	4.57	44.80	5.55
Acetylene	1.00	1.28	1.40	2.12	2.40	4.40
Specific gravity of the gas, calculated	0.7313		0.6182		0.5641	
Specific gravity of the gas by pycnometer	0.7276		0.6113		0.5680	
Percent of useful decomposition of ethane to ethylene	76.0		78.8		78.4	

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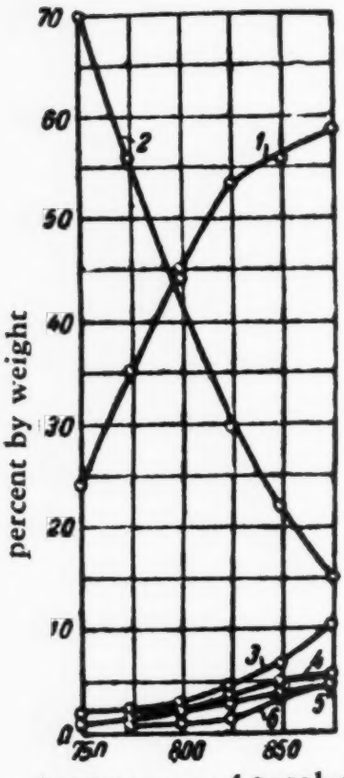

Fig. 5. Dehydrogenation of impure ethane to ethylene with a contact period of 0.3 sec. 1—ethylene; 2—ethane; 3—methane; 4—hydrogen; 5—higher hydrocarbons; 6—acetylene

sults are obtained in pyrolysis of ethane containing a small admixture of ethylene (5-8 percent).

In a second series of experiments the effect of the reaction period at the same temperature on the composition of the products was studied. These experiments carried out at 700 and 750°C. for periods from 0.35 to 13 sec. gave results shown in Tables 5 and 6 and Figs. 6 and 7.

The greatest yield of ethylene at 750°C. and a contact period of 2.9 sec. was 45 percent. The undecomposed ethane under these conditions amounts to 37 percent. The amount of methane is 7.5 percent.

A more prolonged contact period, 9-13 sec., does not reduce materially the amount of ethylene (to 42 percent), but the amount of methane greatly increases, attaining 15 percent. Ethane is decomposed under these conditions as much as 66-70 percent. At this temperature a comparatively small amount of hydrocarbons of higher molecular weight is formed (propane, propylene, butane, and butylene). The amount of still higher hydrocarbons increases as the duration of the reaction increases, to 5.5 percent at 13 sec.

At 700°C., the highest yield of ethylene is 37 percent, and this is obtained in a contact period of 7 sec. The amount of by-products, particularly methane, is only about 4 percent; ethane is decomposed 50 percent. A contact period of 3.5 sec. results in a yield of ethylene of 30 percent; the initial ethane is decomposed to 39 percent. The amount of hydrocarbons of higher molecular weight is negligible.

It is seen from these experiments that at 700-750°C. and 3-7 sec., comparatively high yields of ethylene, 40-45 percent of the initial ethane, can be obtained with 75-70 percent useful decomposition of ethane to ethylene and 50-60 percent total decomposition of the initial ethane.

The undecomposed ethane separated from the reaction products can again be recycled for pyrolysis, producing the same yields.

As the reaction of dehydrogenation of ethane results in an increase in volume and is a reversible reaction it could be assumed that a reduction of the partial pressure of ethane in the reaction zone would bring about an increase in the absolute yield of ethylene. This reduction of the partial pressure of ethane was produced by introducing water vapor into the reaction zone. With small amounts of water, however, about 0.20 cc. per liter of ethane, and a reaction period of 0.1-0.2 sec., experiments at 800-850°C. showed no increased yields of ethylene.

All experiments reported were performed in quartz tubes; it is known that quartz is not an active catalyst in thermal decomposition of hydrocarbons. Comparative experiments of decomposition of ethane under identical conditions of temperature and reaction period were in tubes of different materials in order to clarify the catalytic effect of different materials of the reaction tube on the thermal decomposition of ethane. It was found that at 750-850°C., maintaining the ethane in the reaction zone for short periods of 0.5-1 sec., the material of the tubes has no catalytic effect on the decomposition of ethane.

CONCLUSIONS

[A number of statements made in the text are repeated and the following conclusions are drawn. The basic reactions of decomposition of ethane under the conditions reported above are:

a) $CH_3 \cdot CH_3 \rightarrow CH_2{:}CH_2 + H_2$

b) $2CH_3 \cdot CH_3 \rightarrow 2CH_4 + CH_2{:}CH_2$

Polymerization of ethylene according to Davidson:

c) $\cdot C_2H_4 \rightarrow C_4H_8 \rightarrow C_4H_6 \rightarrow C_6H_6$

At higher temperatures, reactions leading to formation of acetylene, methane, hydrogen, and deposition of carbon play an increasingly large part:

d) $2CH_3 \cdot CH_3 \rightarrow 2CH_4 + CH{:}CH + H_2$

e) $CH_3 \cdot CH_3 \rightarrow C + CH_4 + H_2$

Formation of methane can be explained by hydrogenation of the radicals CH_3, CH_2, and CH formed in

TABLE 4

Temperature of pyrolysis, °C	750		775		800		825		850		875	
Time of exposure of the gas in the reaction zone, sec.	0.41		0.38		0.35		0.33		0.31		0.30	
Increase in volume of the initial gas	1.16		1.27		1.40		1.50		1.71		1.86	
Fractional analysis of the gas by the method of Podbielniak:	% by vol.	% by wt.	% by vol.	% by wt.	% by vol.	% by wt.	% by vol.	% by wt.	% by vol.	% by wt.	% by vol.	% by wt.
Methane	2.93	1.79	3.53	2.33	3.80	2.80	5.40	4.32	7.39	6.78	10.45	10.13
Ethylene	22.56	24.33	30.01	35.04	33.94	44.10	37.93	53.79	34.42	55.72	33.83	57.90
Ethane	60.47	70.61	44.52	56.26	32.05	45.08	19.73	30.29	12.84	22.50	8.19	15.17
Propylene	0.04	0.07	0.17	0.30	0.21	0.42	0.36	0.78	0.35	0.88	0.26	0.69
Propane	0.26	0.48	0.90	1.68	0.92	1.93	0.30	2.84	0.70	1.82	0.74	2.03
Butylene } Butane }	none	none	none	none	0.10	0.26	0.09	0.26	0.10	0.33	0.05	0.17
Higher hydrocarbons	0.51	1.70	0.57	2.06	0.51	2.05	0.67	2.93	0.80	4.00	0.87	4.60
Hydrogen	13.23	1.02	19.70	1.66	27.87	2.61	33.52	3.42	41.40	4.83	43.21	5.33
Acetylene	none	none	0.60	0.67	0.60	0.75	1.00	1.37	2.00	3.14	2.40	3.98
Specific gravity of the gas, calculated	0.8992		0.8310		0.7465		0.6844		0.5992		0.5669	
Percent of useful decomposition of ethane to ethylene	88.0		87.3		86.0		80.0		75.0		74.0	

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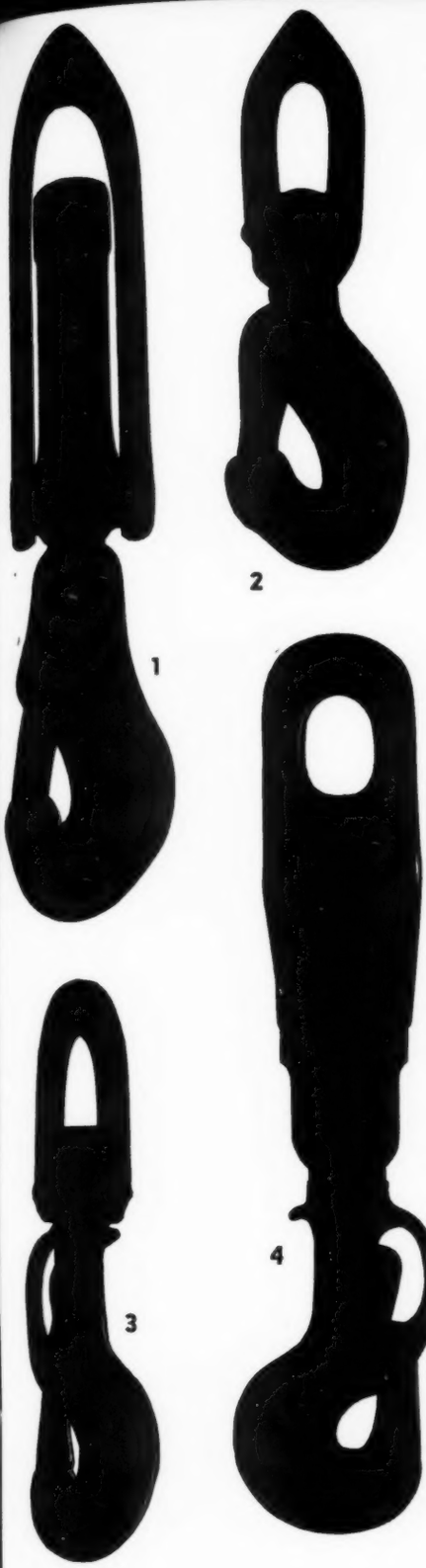

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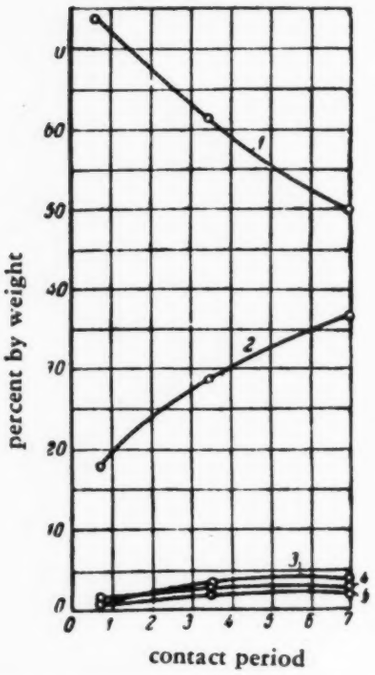

Fig. 6. Dehydrogenation of ethane to ethylene at 700°. 1—ethane; 2—ethylene; 3—methane; 4—higher hydrocarbons; 5—hydrogen

TABLE 6

Dehydration of Ethane to Ethylene at 750°C.

Time of exposure of the gas in the reaction zone, sec.	0.38		2.90		9.10		13.1	
Increase in volume of the initial gas	1.30		1.52		1.55		1.63	
Fractional analysis of the gas by the method of Podbielniak:	% by vol.	% by wt.	% by vol.	% by wt.	% by vol.	% by wt.	% by vol.	% by wt.
Methane	2.80	1.88	8.78	7.20	9.57	7.88	17.28	15.13
Ethylene	22.03	26.18	31.40	45.46	31.05	45.11	27.32	42.21
Ethane	51.60	66.39	23.55	36.91	21.33	33.55	17.62	29.47
Propylene	0.10	0.19	0.35	0.81	0.43	1.00	0.23	0.57
Propane	0.77	1.41	0.64	1.43	1.30	2.90	0.75	1.81
Butylene	0.12	0.29	0.3	0.32	0.17	0.51	0.12	0.38
Butane	0.48	1.76	0.78	3.22	0.90	4.05	1.18	5.64
Higher hydrocarbons	22.10	1.90	33.40	3.50	34.25	3.60	34.90	3.89
Hydrogen	none	none	0.80	1.15	1.00	1.40	0.60	0.90
Specific gravity of the gas, calculated	0.8162		0.6702		0.6677		0.6273	
Specific gravity of the gas by pycnometer	.....		0.6219		0.6589		0.6307	
Percent of useful decomposition of ethane to ethylene	86.6		74.3		71.8		62.4	

decomposition of ethane. This explanation is more plausible as a rise in the temperature of the pyrolysis of ethane greatly increases the amount of hydrogen produced by dehydrogenation of ethane. The experimental data obtained show that dehydrogenation of ethane to ethylene at 700°C. and higher, and a high extent of decomposition does not follow the classical laws of kinetics of chemical reactions and is in better agreement with the results of the work of Dintses and Zherko[24]. It is thought that the most suitable apparatus for pyrolysis of ethane should consist of a tubular furnace of special steel able to withstand prolonged heating at high temperatures. The pyrolysis of ethane should be performed in two stages, the first consisting of preheating to 700°C. and the second, in an instantaneous high-temperature pyrolysis in the shorter part of the apparatus. Use of apparatus of intermittent action having ceramic packing is unsuitable. Elevated pressure reverses the reaction and considerably lowers the yield of ethylene.]

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Fig. 7. Dehydrogenation of ethane to ethylene at 750°. 1—ethylene; 2—ethane; 3—methane; 4—higher hydrocarbons; 5—hydrogen; 6—acetylene

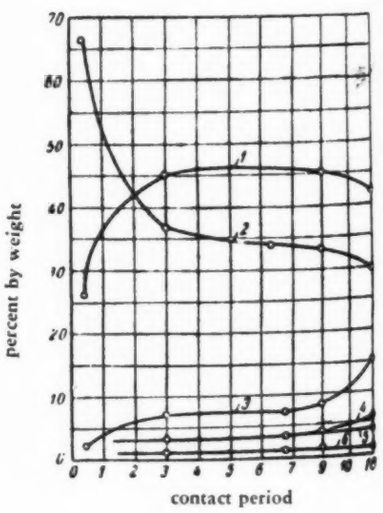

TABLE 5

Results of Dehydration of Ethane to Ethylene at 700°C.

Time of exposure of the gas in the reaction zone, sec.	0.72		3.54		7.20	
Increase in volume of the initial gas	1.18		1.33		1.38	
Fractional analysis of the gas by the method of Podbielniak:	% by vol.	% by wt.	% by vol.	% by wt.	% by vol.	% by wt.
Methane	1.50	0.93	5.23	3.55	5.48	4.02
Ethylene	16.38	17.98	24.16	28.93	28.71	37.12
Ethane	64.76	76.94	47.30	61.32	35.25	49.34
Propylene	0.40	0.68	0.10	0.19	0.33	0.68
Propane			0.72	1.38	0.91	1.82
Butylene	none	.....	0.09	0.22	0.05	0.13
Butane						
Higher hydrocarbons	0.64	2.18	0.68	2.52	0.71	2.84
Hydrogen	16.32	1.29	21.72	1.89	27.36	2.55
Acetylene	none		none		1.20	1.50
Specific gravity of the gas, calculated	0.8836		0.8096		0.7502	
Percent of useful decomposition of ethane to ethylene	82.0		87.0		79.0	

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VOLUME OF LIQUID CONTAINED IN CASING STRINGS, BBL.

Nominal diam. → / I.D. inches →	4¾-in. 4.082	5-in. 4.778	5½-in. 4.892	5½-in. 4.974	5½-in. 5.012	5¾-in. 4.990	5¾-in. 5.090	5¾-in. 5.190	5¾-in. 5.290	6-in. 5.424	6-in. 5.500	6⅝-in.† 5.791	6⅝-in.† 5.855	6⅝-in.† 5.921	6⅝-in.† 6.049	7-in.† 6.154	7-in.† 6.214	7-in.† 6.276	7-in.† 6.336	7-in.† 6.398	7-in.† 6.456	7⅝-in. 6.765	7⅝-in. 6.875	7⅝-in. 6.969
Length of casing, ft.																								
1	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05
2	.03	.04	.05	.05	.05	.05	.05	.05	.05	.06	.06	.07	.07	.07	.07	.07	.07	.08	.08	.08	.08	.09	.09	.09
3	.05	.06	.07	.07	.07	.07	.08	.08	.08	.09	.09	.10	.10	.10	.11	.11	.11	.11	.12	.12	.12	.13	.14	.14
4	.07	.08	.09	.10	.10	.10	.10	.10	.11	.11	.12	.13	.13	.14	.14	.15	.15	.15	.16	.16	.16	.18	.18	.19
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10	.17	.20	.23	.24	.24	.24	.25	.26	.27	.29	.29	.33	.33	.34	.36	.37	.37	.38	.39	.40	.40	.44	.46	.47
20	.33	.40	.46	.48	.49	.48	.50	.52	.54	.57	.59	.65	.67	.68	.71	.74	.75	.77	.78	.80	.81	.89	.92	.94
30	.50	.60	.70	.72	.73	.73	.75	.78	.82	.86	.88	.98	1.00	1.02	1.07	1.10	1.12	1.15	1.17	1.19	1.21	1.33	1.38	1.41
40	.67	.80	.93	.96	.98	.97	1.01	1.05	1.09	1.14	1.17	1.30	1.33	1.36	1.42	1.47	1.50	1.53	1.56	1.59	1.62	1.78	1.84	1.89
50	.83	.99	1.16	1.20	1.22	1.21	1.26	1.31	1.36	1.43	1.47	1.63	1.66	1.70	1.78	1.84	1.87	1.91	1.95	1.99	2.02	2.22	2.29	2.36
60	1.00	1.19	1.39	1.44	1.46	1.45	1.51	1.57	1.63	1.71	1.76	1.95	2.00	2.04	2.13	2.21	2.25	2.30	2.34	2.39	2.43	2.67	2.75	2.83
70	1.17	1.39	1.63	1.68	1.71	1.69	1.76	1.83	1.90	2.00	2.06	2.28	2.33	2.38	2.49	2.57	2.62	2.68	2.73	2.78	2.83	3.11	3.21	3.30
80	1.33	1.59	1.86	1.92	1.95	1.93	2.01	2.09	2.17	2.29	2.35	2.60	2.66	2.72	2.84	2.94	3.00	3.06	3.12	3.18	3.24	3.56	3.67	3.77
90	1.50	1.79	2.09	2.16	2.20	2.18	2.26	2.35	2.44	2.57	2.64	2.93	3.00	3.06	3.20	3.31	3.37	3.44	3.51	3.58	3.64	4.00	4.13	4.24
100	1.67	1.99	2.32	2.40	2.44	2.42	2.52	2.62	2.72	2.86	2.94	3.26	3.33	3.40	3.55	3.68	3.75	3.83	3.90	3.98	4.05	4.44	4.59	4.72
200	3.33	3.98	4.65	4.80	4.88	4.84	5.03	5.23	5.43	5.71	5.87	6.51	6.66	6.81	7.10	7.35	7.50	7.65	7.80	7.95	8.09	8.89	9.18	9.43
300	5.00	5.96	6.97	7.21	7.32	7.25	7.55	7.85	8.15	8.57	8.81	9.76	9.99	10.21	10.66	11.03	11.25	11.48	11.69	11.93	12.14	13.33	13.77	14.15
400	6.66	7.95	9.30	9.61	9.76	9.67	10.06	10.46	10.87	11.43	11.75	13.02	13.32	13.62	14.21	14.71	15.00	15.30	15.59	15.90	16.19	17.78	18.36	18.86
500	8.33	9.94	11.62	12.01	12.20	12.09	12.58	13.08	13.59	14.29	14.69	16.28	16.65	17.02	17.77	18.39	18.75	19.13	19.49	19.88	20.24	22.22	22.95	23.58
600	10.00	11.93	13.94	14.41	14.63	14.51	15.10	15.69	16.30	17.14	17.62	19.54	19.97	20.42	21.32	22.06	22.49	22.95	23.39	23.85	24.28	26.66	27.53	28.30
700	11.66	13.92	16.27	16.81	17.07	16.93	17.61	18.31	19.02	20.00	20.56	22.79	23.30	23.83	24.87	25.74	26.24	26.78	27.29	27.83	28.33	31.11	32.12	33.01
800	13.33	15.90	18.59	19.22	19.51	19.34	20.13	20.92	21.74	22.86	23.50	26.05	26.63	27.23	28.42	29.42	29.99	30.60	31.18	31.80	32.38	35.55	36.71	37.73
900	14.99	17.89	20.92	21.62	21.95	21.76	22.64	23.54	24.45	25.71	26.43	29.30	29.96	30.64	31.98	33.09	33.74	34.43	35.08	35.78	36.42	40.00	41.30	42.44
1,000	16.66	19.88	23.24	24.02	24.39	24.18	25.16	26.15	27.17	28.57	29.37	32.56	33.29	34.04	35.53	36.77	37.49	38.25	38.98	39.75	40.47	44.44	45.89	47.16
2,000	33.32	39.76	46.48	48.04	48.78	48.36	50.32	52.30	54.34	57.14	58.74	65.12	66.58	68.08	71.06	73.54	74.98	76.50	77.96	79.50	80.94	88.88	91.78	94.32
3,000	49.98	59.64	69.72	72.06	73.17	72.54	75.48	78.45	81.51	85.71	88.11	97.68	99.87	102.1	106.6	110.3	112.5	114.8	116.9	119.3	121.4	133.3	137.7	141.5
4,000	66.64	79.52	92.96	96.08	97.56	96.72	100.6	104.6	108.7	114.3	117.5	130.2	133.2	136.2	142.1	147.1	150.0	153.0	155.9	159.0	161.9	177.8	183.6	188.6
5,000	83.30	99.40	116.2	120.1	122.0	120.9	125.8	130.8	135.9	142.9	146.9	162.8	166.5	170.2	177.7	183.9	187.5	191.3	194.9	198.8	202.4	222.2	229.5	235.8
6,000	99.96	119.3	139.4	144.1	146.3	145.1	151.0	156.9	163.0	171.4	176.2	195.4	199.7	204.2	213.2	220.6	224.9	229.5	233.9	238.5	242.8	266.6	275.3	283.0
7,000	116.6	139.2	162.7	168.1	170.7	169.3	176.1	183.1	190.2	200.0	205.6	227.9	233.0	238.3	248.7	257.4	262.4	267.8	272.9	278.3	283.3	311.1	321.2	330.1
8,000	133.3	159.0	185.9	192.2	195.1	193.4	201.3	209.2	217.4	228.6	235.0	260.5	266.3	272.3	284.2	294.2	299.9	306.0	311.8	318.0	323.8	355.5	367.1	377.3
9,000	149.9	178.9	209.2	216.2	219.5	217.6	226.4	235.4	244.5	257.1	264.3	293.0	299.6	306.4	319.8	330.9	337.4	344.3	350.8	357.8	364.2	400.0	413.0	424.4
10,000	166.6	198.8	232.4	240.2	243.9	241.8	251.6	261.5	271.7	285.7	293.7	325.6	332.9	340.4	355.3	367.7	374.9	382.5	389.8	397.5	404.7	444.4	458.9	471.6

Example: After bailing-down a well to 10,895 ft., the 4¾ in. casing string fills with oil to 7922 ft. in 3 hr. What is the rate of fill-up in bbl. per hr.?

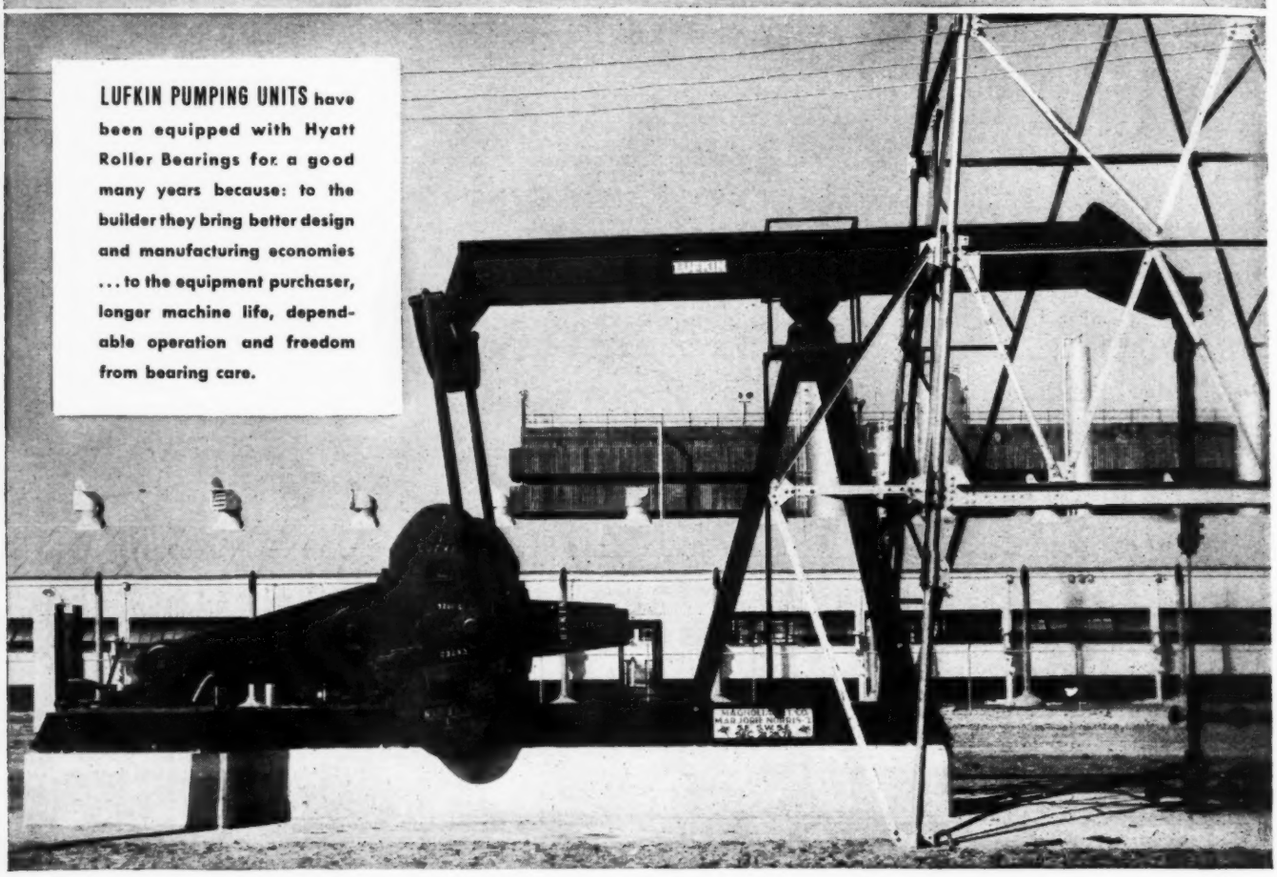
Solution: 10895 — 7922 = 2973

From table:
2000 ft. of 4¾-in. casing contains 33.32 bbl.
900 ft. of 4¾-in. casing contains 14.99 bbl.
70 ft. of 4¾-in. casing contains 1.17 bbl.
3 ft. of 4¾-in. casing contains .05 bbl.
49.53 bbl.

Therefore, the rate of fill-up is 16.51 bbl. per hr.

†Supplementary sizes included by A.P.I. on request of certain districts.

BUILT FOR *Speed and Endurance*



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In the smooth functioning of mechanical equipment the design engineer knows well the importance of Hyatt Roller Bearings . . . how efficiently they operate . . . conserve power . . . obviate wear, attention and replacement. All made possible by the qualities of speed and endurance we build into them. And each succeeding year as they grow greater in performance Hyatts are used in greater numbers. Where and when can we serve you? Hyatt Bearings Division, General Motors Sales Corporation, Harrison, New Jersey; Chicago, Pittsburgh, Detroit and San Francisco.

HYATT *Roller Bearings*

NET WEIGHT OF 2⅜-IN. DRILL PIPE IN ROTARY MUD, LB.

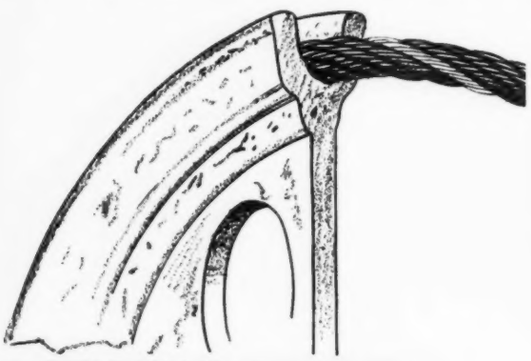
Length of string of drill pipe, ft.	4.80 lb. drill pipe				6.65 lb. drill pipe			
	Weight of fluid				Weight of fluid			
	12.0 lb. per gal.	13.4 lb. per gal.	14.7 lb. per gal.	16.0 lb. per gal.	12.0 lb. per gal.	13.4 lb. per gal.	14.7 lb. per gal.	16.0 lb. per gal.
	90 lb. per cu. ft.	100 lb. per cu. ft.	110 lb. per cu. ft.	120 lb. per cu. ft.	90 lb. per cu. ft.	100 lb. per cu. ft.	110 lb. per cu. ft.	120 lb. per cu. ft.
2,000	7,995	7,810	7,635	7,460	11,250	11,015	10,790	10,570
2,200	8,795	8,590	8,395	8,205	12,375	12,115	11,870	11,625
2,400	9,595	9,370	9,160	8,950	13,500	13,215	12,950	12,685
2,600	10,390	10,150	9,925	9,700	14,630	14,315	14,030	13,740
2,800	11,190	10,930	10,690	10,445	15,750	15,420	15,110	14,800
3,000	11,990	11,710	11,450	11,190	16,880	16,520	16,190	15,855
3,200	12,790	12,495	12,215	11,935	18,005	17,620	17,265	16,910
3,400	13,590	13,275	12,980	12,680	19,130	18,725	18,345	17,970
3,600	14,390	14,055	13,740	13,430	20,255	19,825	19,425	19,025
3,800	15,190	14,835	14,505	14,175	21,380	20,925	20,505	20,085
4,000	15,990	15,615	15,270	14,920	22,505	22,030	21,585	21,140
4,200	16,785	16,400	16,030	15,665	23,630	23,130	22,665	22,195
4,400	17,585	17,180	16,795	16,410	24,755	24,230	23,740	23,255
4,600	18,385	17,960	17,560	17,160	25,880	25,330	24,820	24,310
4,800	19,185	18,740	18,320	17,905	27,005	26,435	25,900	25,370
5,000	19,985	19,520	19,085	18,650	28,130	27,535	26,980	26,425
5,200	20,785	20,300	19,850	19,395	29,255	28,635	28,060	27,480
5,400	21,585	21,080	20,610	20,140	30,380	29,740	29,140	28,540
5,600	22,385	21,860	21,375	20,890	31,505	30,840	30,220	29,595
5,800	23,185	22,645	22,140	21,635	32,630	31,940	31,295	30,655
6,000	23,980	23,425	22,900	22,380	33,755	33,040	32,375	31,710
6,200	24,780	24,205	23,665	23,125	34,880	34,145	33,455	32,765
6,400	25,580	24,985	24,430	23,870	36,005	35,245	34,535	33,825
6,600	26,380	25,765	25,190	24,620	37,130	36,345	35,615	34,880
6,800	27,180	26,545	25,955	25,365	38,255	37,450	36,695	35,940
7,000	27,980	27,330	26,720	26,110	39,380	38,550	37,770	36,995
7,200	28,780	28,110	27,480	26,860	40,505	39,650	38,850	38,050
7,400	29,580	28,890	28,245	27,600	41,630	40,750	39,930	39,110
7,600	30,375	29,670	29,010	28,350	42,760	41,855	41,010	40,165
7,800	31,175	30,450	29,775	29,095	43,885	42,955	42,090	41,225
8,000	31,975	31,230	30,535	29,840	45,010	44,055	43,170	42,280
8,200	32,775	32,010	31,300	30,585	46,135	45,155	44,245	43,335
8,400	33,575	32,795	32,065	31,330	47,260	46,260	45,325	44,395
8,600	34,375	33,575	32,825	32,080	48,385	47,360	46,405	45,450
8,800	35,175	34,355	33,590	32,825	49,510	48,460	47,485	46,510
9,000	35,975	35,135	34,355	33,570	50,635	49,565	48,565	47,565
9,200	36,770	35,915	35,115	34,315	51,760	50,665	49,645	48,620
9,400	37,570	36,700	35,880	35,060	52,885	51,765	50,720	49,680
9,600	38,370	37,480	36,645	35,810	54,010	52,865	51 800	50,735
9,800	39,170	38,260	37,405	36,555	55,135	53,970	52,880	51,795
10,000	39,970	39,040	38,170	37,300	56,260	55,070	53,960	52,850
10,200	40,770	39,820	38,935	38,045	57,385	56,170	55,040	53,905
10,400	41,570	40,600	39,695	38,790	58,510	57,270	56,120	54,965
10,600	42,370	41,380	40,460	39,540	59,635	58,370	57,200	56,020
10,800	43,170	42,160	41,225	40,285	60,760	59,475	58,280	57,080
11,000	43,965	42,945	41,985	41,030	61,885	60,575	59,355	58,135
11,200	44,765	43,725	42,750	41,775	63,010	61,680	60,435	59,190
11,400	45,565	44,505	43,515	42,520	64,135	62,780	61,515	60,250
11,600	46,365	45,285	44,275	43,270	65,260	63,880	62,595	61,305
11,800	47,165	46,065	45,040	44,015	66,385	64,985	63,675	62,365
12,000	47,965	46,850	45,805	44,760	67,510	66,085	64,750	63,420
12,200	48,765	47,630	46,570	45,505	68,635	67,185	65,830	64,475
12,400	49,565	48,410	47,330	46,250	69,760	68,285	66,910	65,535
12,600	50,360	49,190	48,095	47,000	70,890	69,390	67,990	66,590
12,800	51,160	49,970	48,860	47,745	72,015	70,490	69,070	67,650
13,000	51,960	50,750	49,620	48,490	73,140	71,590	70,150	68,705

NOTE: For other data pertaining to weight and volume of 2⅜-in. drill pipe, see table P 425.240.237.

HOW SHEAVE MATERIALS AFFECT WIRE ROPE SERVICE

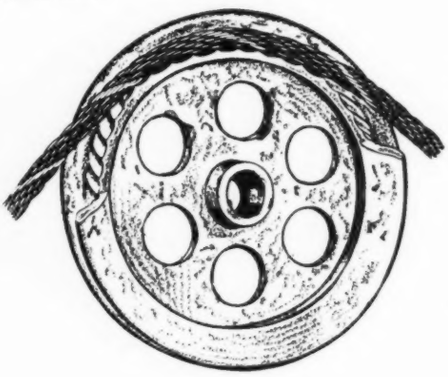
No. 2 in a series of informative articles for wire rope users, prepared by the MACWHYTE *wire rope company*

WATCH YOUR SHEAVES! *And Get Longer Wire Rope Service*



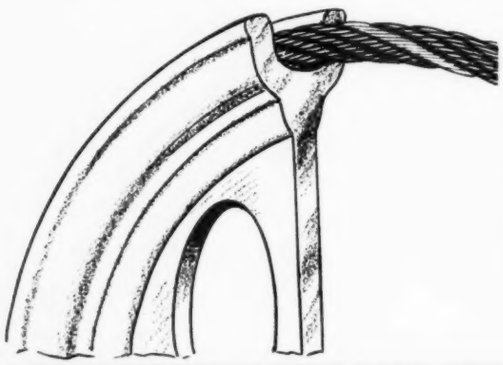
1. THIS DAMAGES YOUR ROPE

(a) Deep scoring of soft sheaves, pinch the rope and cause it to scrub on sheave flange.



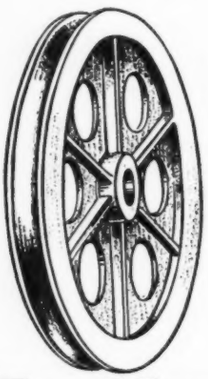
(b) SOFT SHEAVE often corrugates. A new rope does not "track" in the corrugations — Result — less wire rope service.

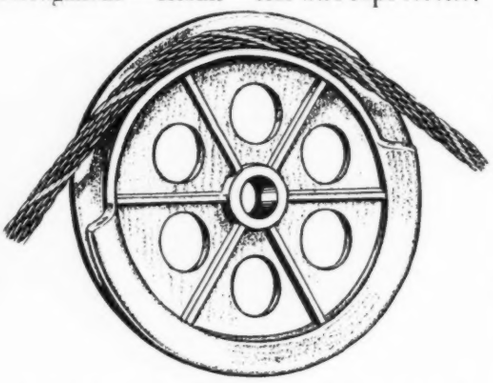
NOTE: *Tear out . . . put in your wire rope maintenance file*



2. THIS LENGTHENS YOUR ROPE SERVICE

(c) A hard sheave does not easily score deeply and damage the rope.





(d) The smooth wearing surface of a hard sheave gives the rope a smooth bearing surface that lengthens the life of both sheave and wire rope.

3. IT IS FALSE ECONOMY to Operate Wire Rope Over Badly Scored and Corrugated Sheaves. WATCH YOUR SHEAVES . . . Keep Them Smooth . . . And Get Longer Wire Rope Service! The benefit of our experience on any problem pertaining to wire rope and its use is yours for the asking. It is part of our friendly service.

Contradictory as it may seem, a *soft* iron sheave that wears rapidly will cause more wear on a wire rope than sheaves made with *harder* materials.

Why Soft Sheaves Cause More Wear on Wire Rope.

A sheave of softer material than the wire rope is likely to take an impression of the wire rope and become deeply scored and corrugated, presenting a ragged surface which damages the rope and causes excessive wear.

A NEW WIRE ROPE USED ON A CORRUGATED SHEAVE WILL NOT "TRACK" IN THE CORRUGATIONS MADE BY THE PREVIOUS ROPE. IT WILL WEAR RAPIDLY AND NOT GIVE MAXIMUM SERVICE. THE GROOVE WILL ALSO WEAR DEEP AND THE FLANGE OF THE SHEAVE WILL CAUSE EXCESSIVE WEAR.

Why Hard Sheaves Increase Wire Rope Service.

Sheaves made of harder materials . . . such as carbon steel, manganese, other alloys, or "work-hardening" steels . . . wear smooth, last longer and allow the rope to give the best service.

MACWHYTE COMPANY
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LENGTH OF A.P.I. STD. ROTARY CHAIN—NO. OF PITCHES (OR LINKS) IN IN., AND FT. AND IN. (TO NEAREST 1/16 IN.)

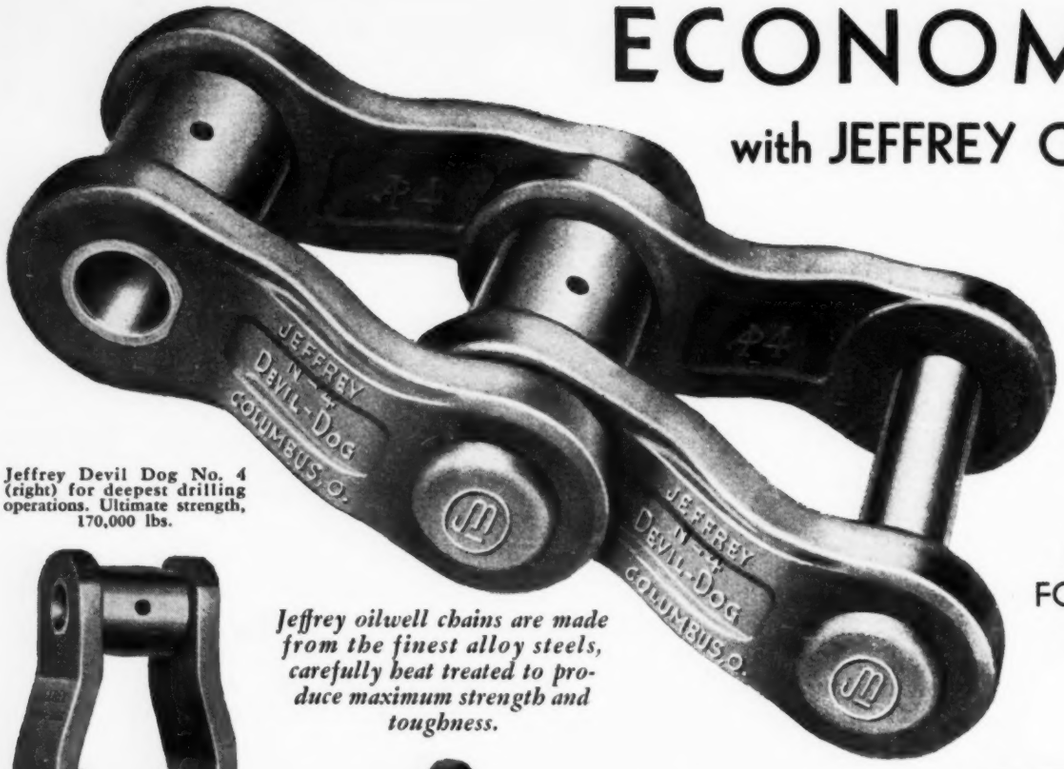
No. of pitches (or links)	A.P.I. Chain No. 3[1] pitch (P) = 3.075 in.						A.P.I. Chain No. 3 1/8[2] pitch (P) = 3.125 in.				A.P.I. Chain No. 4[3] pitch (P) = 4.063 in.					
	Commercial type				Precision type†		Precision type				Commercial type				Precision type†	
	minimum length,		maximum length,		maximum length,		minimum length,		maximum length,		minimum length,		maximum length,		maximum length,	
	in.	ft. and in. (nearest 1/16 in.)	in.	ft. and in. (nearest 1/16 in.)	in.	ft. and in. (nearest 1/16 in.)	in.	ft. and in. (nearest 1/16 in.)	in.	ft. and in. (nearest 1/16 in.)	in.	ft. and in. (nearest 1/16 in.)	in.	ft. and in. (nearest 1/16 in.)	in.	ft. and in. (nearest 1/16 in.)
1	3.075	0- 3 1/16	3.081	0- 3 1/16	3.079	0- 3 1/16	3.125	0- 3 1/8	3.129	0- 3 1/8	4.063	0- 4 1/16	4.071	0- 4 1/16	4.068	0- 4 1/16
2	6.150	0- 6 1/8	6.162	0- 6 3/16	6.158	0- 6 3/16	6.250	0- 6 1/4	6.258	0- 6 1/4	8.126	0- 8 1/8	8.142	0- 8 1/8	8.136	0- 8 1/8
3	9.225	0- 9 1/4	9.243	0- 9 1/4	9.237	0- 9 1/4	9.375	0- 9 3/8	9.387	0- 9 3/8	12.189	1- 0 3/16	12.213	1- 0 3/16	12.204	1- 0 3/16
4	12.300	1- 0 5/16	12.325	1- 0 5/16	12.315	1- 0 5/16	12.500	1- 0 1/2	12.516	1- 0 1/2	16.252	1- 4 1/4	16.285	1- 4 5/16	16.272	1- 4 1/4
5	15.375	1- 3 3/8	15.406	1- 3 3/8	15.394	1- 3 3/8	15.625	1- 3 5/8	15.645	1- 3 5/8	20.315	1- 8 5/16	20.356	1- 8 3/8	20.340	1- 8 5/16
6	18.450	1- 6 7/16	18.487	1- 6 1/2	18.473	1- 6 1/2	18.750	1- 6 3/4	18.773	1- 6 3/4	24.378	2- 0 3/8	24.427	2- 0 7/16	24.408	2- 0 7/16
7	21.525	1- 9 1/2	21.568	1- 9 9/16	21.552	1- 9 1/2	21.875	1- 9 7/8	21.902	1- 9 7/8	28.441	2- 4 7/16	28.498	2- 4 1/2	28.477	2- 4 1/2
8	24.600	2- 0 5/8	24.649	2- 0 5/8	24.631	2- 0 5/8	25.000	2- 1	25.031	2- 1 1/16	32.504	2- 8 1/2	32.569	2- 8 9/16	32.545	2- 8 9/16
9	27.675	2- 3 11/16	27.730	2- 3 3/4	27.710	2- 3 11/16	28.125	2- 4 1/8	28.160	2- 4 3/16	36.567	3- 0 9/16	36.640	3- 0 5/8	36.613	3- 0 5/8
10	30.750	2- 6 3/4	30.812	2- 6 13/16	30.788	2- 6 13/16	31.250	2- 7 1/4	31.289	2- 7 5/16	40.630	3- 4 5/8	40.711	3- 4 11/16	40.681	3- 4 11/16
11	33.825	2- 9 13/16	33.893	2- 9 7/8	33.867	2- 9 7/8	34.375	2-10 3/8	34.418	2-10 7/16	44.693	3- 8 11/16	44.782	3- 8 13/16	44.749	3- 8 3/4
12	36.900	3- 0 7/8	36.974	3- 1	36.946	3- 0 15/16	37.500	3- 1 1/2	37.547	3- 1 9/16	48.756	4- 0 3/4	48.854	4- 0 7/8	48.817	4- 0 13/16
13	39.975	3- 4	40.055	3- 4 1/16	40.025	3- 4	40.625	3- 4 5/8	40.676	3- 4 11/16	52.819	4- 4 13/16	52.925	4- 4 15/16	52.885	4- 4 7/8
14	43.050	3- 7 1/16	43.136	3- 7 1/8	43.104	3- 7 1/8	43.750	3- 7 3/4	43.805	3- 7 13/16	56.882	4- 8 7/8	56.996	4- 9	56.953	4- 8 15/16
15	46.125	3-10 1/8	46.217	3-10 3/16	46.183	3-10 3/16	46.875	3-10 7/8	46.934	3-10 15/16	60.945	5- 0 15/16	61.067	5- 1 1/16	61.021	5- 1
16	49.200	4- 1 3/16	49.298	4- 1 5/16	49.262	4- 1 1/4	50.000	4- 2	50.063	4- 2 1/16	65.008	5- 5	65.138	5- 5 1/8	65.089	5- 5 1/16
17	52.275	4- 4 1/4	52.380	4- 4 3/8	52.340	4- 4 5/16	53.125	4- 5 1/8	53.191	4- 5 3/16	69.071	5- 9 1/16	69.209	5- 9 3/16	69.157	5- 9 3/16
18	55.350	4- 7 3/8	55.461	4- 7 7/16	55.419	4- 7 7/16	56.250	4- 8 1/4	56.320	4- 8 5/16	73.134	6- 1 1/8	73.280	6- 1 1/4	73.225	6- 1 1/4
19	58.425	4-10 7/16	58.542	4-10 9/16	58.498	4-10 1/2	59.375	4-11 3/8	59.449	4-11 7/16	77.197	6- 5 3/16	77.351	6- 5 3/8	77.293	6- 5 5/16
20	61.500	5- 1 1/2	61.623	5- 1 5/8	61.577	5- 1 9/16	62.500	5- 2 1/2	62.578	5- 2 9/16	81.260	6- 9 1/4	81.423	6- 9 7/16	81.362	6- 9 3/8
21	64.575	5- 4 9/16	64.704	5- 4 11/16	64.656	5- 4 5/8	65.625	5- 5 5/8	65.707	5- 5 11/16	85.323	7- 1 5/16	85.494	7- 1 1/2	85.430	7- 1 7/16
22	67.650	5- 7 5/8	67.785	5- 7 3/4	67.735	5- 7 3/4	68.750	5- 8 3/4	68.836	5- 8 13/16	89.386	7- 5 3/8	89.565	7- 5 9/16	89.498	7- 5 1/2
23	70.725	5-10 3/4	70.866	5-10 7/8	70.813	5-10 13/16	71.875	5-11 7/8	71.965	5-11 15/16	93.449	7- 9 7/16	93.636	7- 9 5/8	93.566	7- 9 9/16
24	73.800	6- 1 13/16	73.948	6- 1 15/16	73.892	6- 1 7/8	75.000	6- 3	75.094	6- 3 1/16	97.512	8- 1 1/2	97.707	8- 1 11/16	97.634	8- 1 5/8
25	76.875	6- 4 7/8	77.029	6- 5	76.971	6- 5	78.125	6- 6 1/8	78.223	6- 6 1/4	101.575	8- 5 9/16	101.778	8- 5 3/4	101.702	8- 5 11/16
26	79.950	6- 7 15/16	80.110	6- 8 1/8	80.050	6- 8 1/16	81.250	6- 9 1/4	81.352	6- 9 3/8	105.638	8- 9 5/8	105.849	8- 9 7/8	105.770	8- 9 3/4
27	83.025	6-11	83.191	6-11 3/16	83.129	6-11 1/8	84.375	7- 0 3/8	84.480	7- 0 1/2	109.701	9- 1 11/16	109.920	9- 2	109.838	9- 1 13/16
28	86.100	7- 2 1/8	86.272	7- 2 1/4	86.208	7- 2 3/16	87.500	7- 3 1/2	87.609	7- 3 5/8	113.764	9- 5 3/4	113.992	9- 6	113.906	9- 5 7/8
29	89.175	7- 5 3/16	89.353	7- 5 3/8	89.286	7- 5 5/16	90.625	7- 6 5/8	90.738	7- 6 3/4	117.827	9- 9 13/16	118.063	9-10 1/16	117.974	9-10
30	92.250	7- 8 1/4	92.435	7- 8 7/16	92.365	7- 8 3/8	93.750	7- 9 3/4	93.867	7- 9 7/8	121.890	10- 1 7/8	122.134	10- 2 1/8	122.042	10- 2 1/16
31	95.325	7-11 5/16	95.516	7-11 1/2	95.444	7-11 7/16	96.875	8- 0 7/8	96.996	8- 1	125.953	10- 5 15/16	126.205	10- 6 3/16	126.110	10- 6 1/8
32	98.400	8- 2 3/8	98.597	8- 2 5/8	98.523	8- 2 1/2	100.000	8- 4	100.125	8- 4 1/8	130.016	10-10	130.276	10-10 1/4	130.179	10-10 3/16
33	101.475	8- 5 1/2	101.678	8- 5 11/16	101.602	8- 5 5/8	103.125	8- 7 1/8	103.254	8- 7 1/4	134.079	11- 2 1/16	134.347	11- 2 3/8	134.247	11- 2 1/4
34	104.550	8- 8 9/16	104.759	8- 8 3/4	104.681	8- 8 11/16	106.250	8-10 1/4	106.383	8-10 3/8	138.142	11- 6 1/8	138.418	11- 6 7/16	138.315	11- 6 5/16
35	107.625	8-11 5/8	107.840	8-11 13/16	107.760	8-11 3/4	109.375	9- 1 3/8	109.512	9- 1 1/2	142.205	11-10 5/16	142.489	11-10 1/2	142.383	11-10 3/8

†—Precision type has same minimum specification as commercial type.
[1]—Corresponds to old numbers 1030 and SS-40.
[2]—Available in precision type only.
[3]—Corresponds to old numbers 1240 and SS-124.

NOTE: Standard tension for measuring standard 10-ft. lengths: 500 lb. per sq. in.

ECONOMIZE

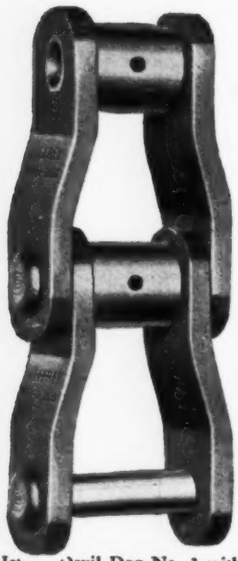
with JEFFREY OILWELL CHAINS



Jeffrey Devil Dog No. 4 (right) for deepest drilling operations. Ultimate strength, 170,000 lbs.

Jeffrey oilwell chains are made from the finest alloy steels, carefully heat treated to produce maximum strength and toughness.

A CHAIN FOR EVERY DEPTH

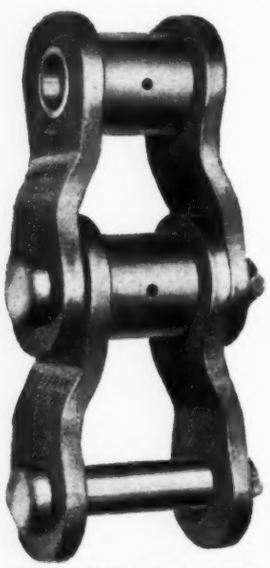


Jeffrey Devil Dog No. 3 with ultimate strength of 75,000 lbs. Pitch is 3.075 inches.

A breakdown of the No. 4 Devil Dog oilwell chain showing features of construction. Note the double DD shank in side bar into which the heat treated pins are securely locked.

Boxed in ten-foot coils, Jeffrey chains are completely protected from dirt in warehousing, transportation and handling in the field. Boxes are clearly labeled to facilitate replacement service.

Jeffrey Rotor Chief No. 103 RC for average to deep drilling. Ultimate strength, 60,000 lbs.



Single strand 3125-A oilwell chain with 115,000 lbs. ultimate strength and 3.125 pitch. Also double strand Ranger chains with 230,000 lbs. ultimate strength. Used for deep, high speed drilling.

PRECISION manufacturing methods applied to the finest alloy steels is the combination which makes Jeffrey oilwell chains the leaders in the Petroleum Industry. They are capable of withstanding present-day high speed drilling . . . have that nicety of balance which means maximum strength for minimum weight, yet with ample safety factors to withstand unexpected overloads.

On the "draw works" Jeffrey chains will stand up under many round trips . . . will take the shock of sudden stopping and rapid entry into the hole. On the "rotor drives" they are built for the extreme high speeds and shock loads.

Jeffrey oilwell chains conform to A.P.I. dimensional standards. Try them on your next job if you desire extra economy and long life. Send for Catalog No. 708.

The Jeffrey Mfg. Co.

897-99 North Fourth Street, Columbus, Ohio

Calculation of Transfer Area in Heat Exchangers

Part 2 (Concluded)

By JOHN GRISWOLD

Assistant Professor of Chemical Engineering, University of Texas

Determination of the Film Coefficient

The film coefficient of a fluid depends upon the rate and hence, the type of flow as measured by the Reynolds Number expressed variously as (DG/μ), $(DV\rho/\mu)$, or (Re). To consider all conditions of flow it is helpful to divide the rates into three zones: viscous, transitional, and turbulent. It is important to consider the transitional zone because the flow does not change abruptly from one distinct type to the other. This distinction must be made because the type of flow directly affects the value of h, and all three zones may be encountered normally in equipment handling viscous liquids.

The three zones may be defined approximately by the limiting values of (Re) as follows:

Type of flow	*Values of (Re)*
Viscous . . .	Less than 2100
Transitional .	2100 to 7000
Turbulent . .	More than 7000

McAdams and Gilliland[1(a)] do not consider strong turbulence exists until (Re) exceeds 14,000. A heat-transfer film correlation of viscous oils[3], however, shows that (Re) = 7000 is a satisfactory limit at which to assume that the viscous-flow effect becomes negligible as the value of (Re) increases.

It is apparent that three distinct correlations of film coefficients will be required to cover the entire range of flow rates. For the turbulent zone, Colburn's equation[4] applies:

$$\left[\frac{h_{tb}}{CG}\right]\left[\frac{C\mu_t}{k}\right]^{2/3} = 0.023\left[\frac{DG}{\mu_t}\right]^{-0.2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

Equation (4) may be applied to any kind of fluid.

For the zone of viscous-flow, economics of design and operation dictate that this condition of flow should be limited almost exclusively to viscous oils in tube-sizes usually employed. For this condition, McAdams and Gilliland recommend the correlation:

$$\left[\frac{h_{vl}D}{k}\right] = 2.0\left[\frac{wC}{kN}\right]^{1/3}\left[\frac{\mu}{\mu_w}\right]^{0.14} \quad . \quad (5)$$

No general equation has been developed to correlate h in the transitional zone because of the erratic conditions that prevail in this region.

A biographical sketch and photograph of the author can be found on page 42 of the June issue of *The Petroleum Engineer*, in connection with Part 1 of this article.

Fig. 4 is a graphical correlation for the film coefficient of viscous-oil in both viscous and transitional zones based on data by Sieder and Tate but re-plotted by McAdams and Gilliland using a different ordinate.

Graphical Integration of the Heat Transfer Equation

Considering the heat-transfer to the liquid inside the tubes, the heat transmitted through the tube-wall raises the liquid temperature in accordance with the basic equation:

$$q = A\,U\,(T - t)_{av.} = W\,C \int dt$$

Rearranging:

$$\frac{A}{W\,C} = \int_{t_1}^{t_2} \frac{dt}{U(T - t)}$$

$$= \int_{t_1}^{t_2} \frac{(r + 1/h_l)\,dt}{(T - t)} \quad . \quad . \quad (6)$$

For conditions of Case (3) only, an average value of T may be treated as a constant. To evaluate A, the right-hand side of Equation (6) must be integrated. This is done graphically when U_l is not linear with Δ as h_l is essentially an irrational power function of the liquid viscosity appearing in a form that has never been integrated successfully. The graphical integration is accomplished by plotting values of the function

$$(r + 1/h_l)/(T - t)$$

as ordinates against accompanying values of t as abscissas. The area under the resulting curve between the limits of t_1 and t_2 is equal to A/WC. To construct a curve of this kind values of h_l at a number of temperature intervals are either calculated from Equations (4) and (5) or interpolated from Fig. 4, depending on the range of (Re) values existing in the heat exchanger.

Suggested Methods of Simplifying Calculation

The increase in temperature of the liquid effects a change in the C, k, and μ values that appear in Equations (4) and (5). Viscosity, μ, however, is the only variable changing appreciably. Variation in C and k and the effect on h is very slight. The practice of using values of C and k based on the average liquid temperature does not introduce appreciable error. The viscosity at the tube-wall temperature (μ_w), which appears in Equation (5) and Fig. 4, will also be virtually constant and may be so treated. In any specific problem, therefore, the remaining viscosity functions may be collected and factored-out, resulting in an equation in which h_l is expressed in terms of a specific constant and viscosity is the only variable. This simplified treatment will now be developed for each of the three flow-rate zones.

Turbulent flow. Solving Equation (4) for h and factoring out the viscosity functions:

$$h_{tb} = 0.023\left[\frac{k}{D}\right]\left[\frac{k}{C\mu_t}\right]^{2/3}\left[\frac{DG}{\mu_t}\right]^{-0.2}$$

$$= 0.023\left[\frac{k}{D}\right]\left[\frac{k}{C}\right]^{2/3}\left[\frac{DG}{1}\right]^{-0.2}(\mu_t)^{-0.467}$$

$$= \frac{1}{(\gamma_{tb})\,(\mu_t)^{0.467}} \quad (4a)$$

Equation (4a) defines γ as a specific constant grouping k, D, C, and G for

[1(a)] *Op. Cit.*, pp. 127-30.
[3] Sieder, E. N. and Tate, G. E. *Ind. Eng. Chem.*, 28, 1429, (1936).
[4] Colburn, A. P., *Tr. A.I. Ch. E.* 29, 174, (1933).

any particular problem. It may be evaluated either by factoring a definite value of h or by direct calculation from the constants involved.

The film viscosity (μ_t) is defined by Colburn as the viscosity of the film at the film temperature, which may be assumed without serious error to be the arithmetic average temperature between the tube-wall and the main body of the fluid:

$$t_f = \frac{t_w + t}{2}$$

Viscous flow. A similar procedure may be followed to obtain a specific form of Equation (5) for viscous flow:

$$\gamma_{vi} = \frac{(\mu)^{0.14}}{h_{vi}} \quad . \quad . \quad . \quad (5a)$$

Transitional flow. Values of h_{tr} may be obtained accurately only from a graph such as Fig. 4. The coördinates of the chart include all the factors influencing both viscous and turbulent flow coefficients. The ordinate may be simplified by factoring the viscosity terms as was done for Equations (4a) and (5a):

$$h\left[\frac{(\mu_w)^{0.14}}{(G)\ (C)^{1/3}\ (k)^{2/3}}\right](\mu)^{0.53} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

$$h(\beta)\ (\mu)^{0.53} \quad . \quad . \quad . \quad . \quad . \quad (7a)$$

This manipulation permits β to be defined as a constant for a specific problem.

Temperature-Viscosity Relation for Oils and Its Use in Calculations

It is essential in heat transfer calculations that the viscosity of the liquid be known at the temperatures at which h is to be considered.

A number of empirical equations are available for relating viscosity to temperature. Most of these require at least three constants, determined empirically.

Herschel[5] and Fortsch and Wilson[6] have shown that viscosity in absolute units plotted against temperature in °F. results in curves that are nearly straight lines on logarithmic coördinate paper for temperatures above 30°F. A straight line on log paper is represented by the equation:

$$\mu = \frac{b}{(t°F)^a} \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

As Equation (8) contains only the two empirical constants, a and b, it may be used conveniently.

The viscosity of petroleum oils is ordinarily expressed in Saybolt Universal Seconds at 100° F. and 210° F. These figures may be converted into kinematic units by the use of the A.S.T.M. equations[7], or by a conversion table.

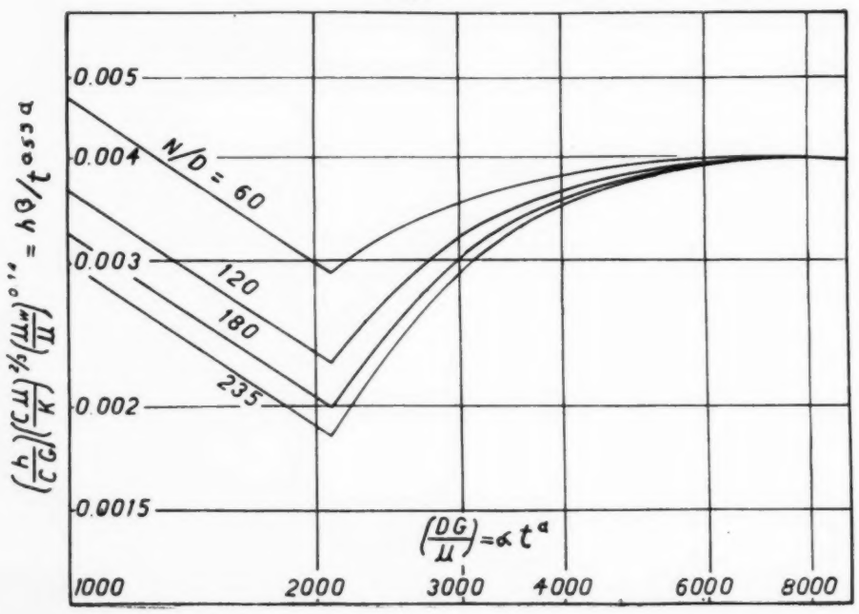
Viscosity in the heat transfer equations treated here is expressed in the units lb./hr-ft. = 2.42 × centipoises. The constants in Equation (8) may be evaluated in lb./hr-ft. from viscosities at 100° F. and 210° F. by the relations:

$$a = 3.1035 \log_{10}\left[\frac{\mu_{100}}{\mu_{210}}\right] \quad . \quad (8a)$$

$$b = \log^{-1}\left[\log \mu_{210} + 2.3222a\right] \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8b)$$

[5]Herschel, W. H., *Ind. Eng. Chem.*, *14*, No. 8, 715 (1922).
[6]Fortsch, A. R., and Wilson, R. E., *ibid.*, *16*, 789 (1924).
[7]D-341-32T, Sec. 6, *Standards on Petroleum Products and Lubricants*, A.S.T.M., Philadelphia, Pennsylvania.

Fig. 4



The accuracy of Equation (8) is satisfactory for temperatures above 30° F. to reasonably higher values. For temperatures lower than 30° F. or extremely high temperatures the constants a and b should be evaluated from viscosity data that cover the temperatures considered.

When a large number of point values are to be calculated for a graphical integration, the computations become laborious. These computations may be simplified by expressing Equations (4a) and (5a) in terms of temperature only, by combining them with Equation (8). The same scheme may also be used to express both coördinates of Fig. 4 in terms of temperature only. Equation (4a) becomes:

$$h_{tb} = \frac{\left[\frac{t_w + t}{2}\right]^{0.467a}}{(\gamma_{tb})\ (b)^{0.467}} \quad . \quad . \quad . \quad (4b)$$

Substitution of (4b) into (6) results in the equation for calculating the heat transfer surface area:

$$\frac{A}{WC} = \int_{t_1}^{t_2}\left[\frac{r + (\gamma)\ (b)^{0.467}}{(T - t)\left(\frac{t_w + t}{2}\right)^{0.467a}}\right](dt) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4c)$$

The right-hand side of Equation (4c) is the equivalent of $\frac{dt}{U_{tb}(T-t)}$. It may be used to calculate point values for graphical integration between t_1 and t_2 when both points are in the turbulent zone.

For viscous flow conditions, Equations (5b) and (6) combined result in the equation:

$$\frac{A}{WC} = \int_{t_1}^{t_2}\left[\frac{r + (\gamma_{vi})\ (t^{0.14a})\ (b^{-0.14})}{(T - t)}\right]dt \quad . \quad . \quad . \quad . \quad . \quad (5c)$$

For problems involving transitional flow, the abscissa of Fig. 4 becomes:

$$\left[\frac{DG}{\mu}\right] = \left[\frac{DG}{b/t^a}\right] = (DG/b)\ (t^a) = \alpha t^a$$

The ordinate of Fig. 4 becomes:

$$h(\beta)\ (\mu^{0.53}) = h\frac{\beta'}{t^{0.53a}} \quad . \quad . \quad (7b)$$

Calculated values of h are then used in Equation (6).

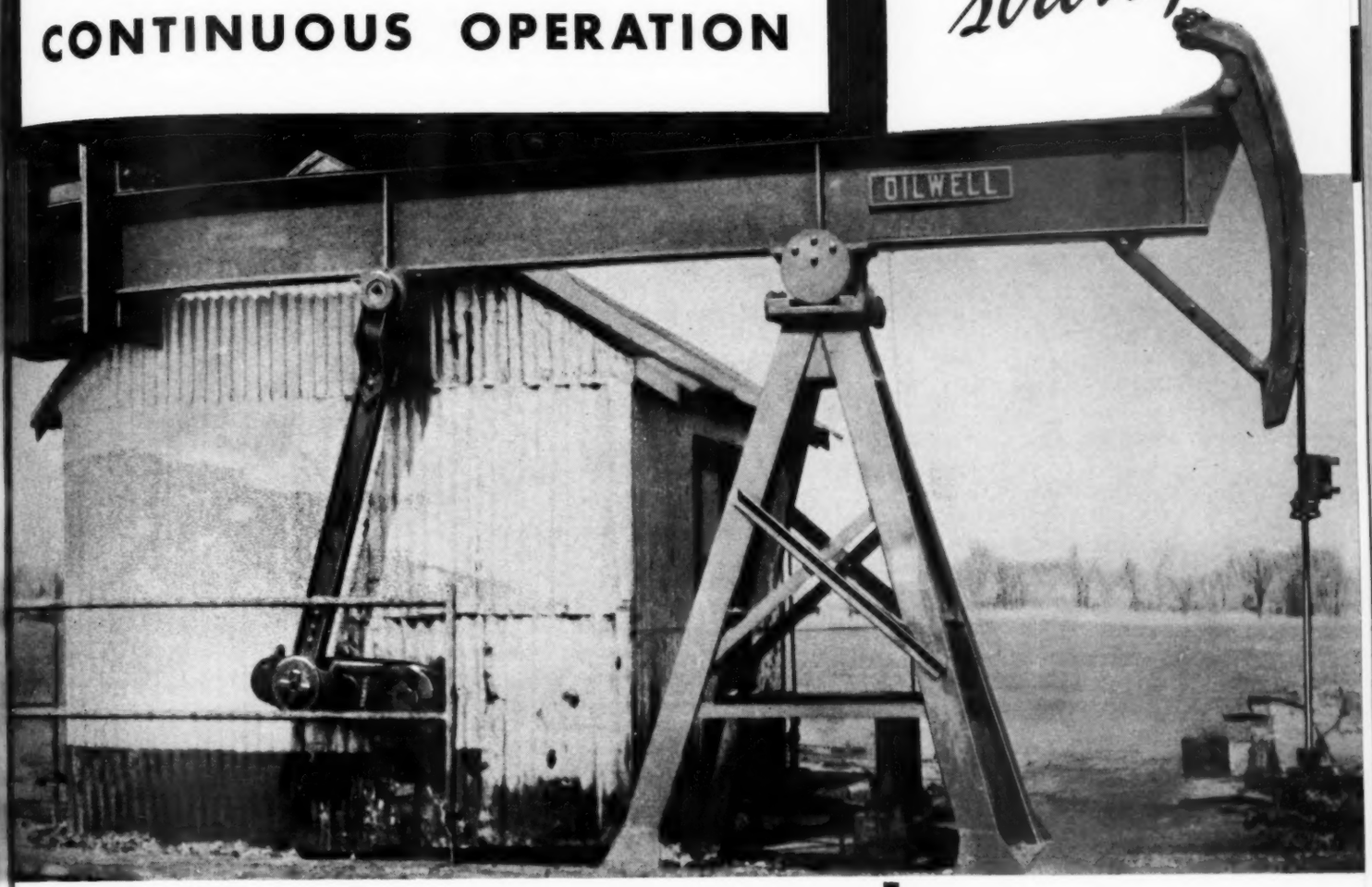
Example

A concrete problem involving Case (3) is McAdams and Gilliland's Illustration 3, p. 129*:

*By permission.

YEARS OF CONTINUOUS OPERATION

—and still going strong!



"Oilwell" ODH-18 Pumping Unit No. T11-4 was installed on December 10, 1933, in the Ritz-Canton field near McPherson, Kansas, on a 2952-ft. well. It has been in continuous service ever since. This unit is now pumping with ¾-in. rods through 2½-in. tubing at seventeen to twenty-one 37½-in. strokes per minute. Service in its earlier years is said to have been more severe, including many back-breaking potential tests.

This *"Oilwell"* Pumping Unit in Kansas will soon have completed 50,000 hours of hard service with its original working parts in excellent condition

PUMPING service in Kansas with its endurance-testing potentials has not been easy. When a unit which has been subjected to such service continues to perform as this one and hundreds of others are doing, consideration must be given to the reasons for its stamina. Here are four:

1. **Conservative Rating — an Established "Oilwell" Policy.**
2. **Fully Heat-Treated, Single-Helical Gears and Pinions.**
3. **Precision Alignment of the Shafting Is Maintained by Simple Shim-Adjustment of the Tapered Roller Bearings.**
4. **Over-size Bearings, Pins and Shafts Throughout with Ample Provisions for Lubrication and Weatherproofing.**

The present ***"Oilwell"*** Pumping Units and Speed Reducers have these same fundamental advantages. In addition, refinements and new features give improved efficiency and convenience and assure even greater dependability.

Consult the nearest ***"Oilwell"*** branch regarding your production equipment needs.

"Oilwell"

OIL WELL SUPPLY COMPANY

81,000 lb. per hr. of a hydrocarbon oil are to be heated in a tubular exchanger from 75° F. to 200° F. with steam condensing at 240° F. The oil is to be pumped through the tubes at a velocity of 3 ft. per sec. The tubes are 16 ft. long, made of Admiralty metal, 1 in. O.D., 0.902 in. I.D., $k = 60$. The properties of the oil are: $C = 0.52$, $k = 0.091$, $\rho = 56.4$ lb. per cu. ft. Data from a plot of viscosity at various temperatures are given below. Calculate the sq. ft. of heating surface required.

t, °F.	μ, lb./hr-ft.	b/t^a*
60	66	69.5
80	40	39.1
100	26.5	25.0
120	18	17.4
160	10	9.8
200	6.2	6.25
240	4.2	4.3

*Trial values for a and b show:

$$b/t^a = \frac{(2.5)\ (10^5)}{t^{2.0}}$$

Values of a and b of 2.5×10^5 and 2.0, respectively, for Equation (8) fit the test data satisfactorily. Assuming 1000 B.t.u. per hr. per sq. ft. per °F. as the steam, film, and scale coefficient, the fixed resistance is:

$$r = r_{\text{tube-wall}} + 1/h_{\text{steam, film, and scale}}$$

$$= \frac{(1.0-0.902)\div 2\times 12}{60\times 0.951\div 0.902} + \frac{1}{1000\,(1.0\div 0.902)} = 0.00097.$$

$$Re = \frac{DV\rho}{\mu} = \frac{\frac{0.902}{12}\times 3\times 3600\times 56.4}{\frac{2.5\times 10^5}{t^{2.0}}} = 0.18\ t^{2.0}$$

As Re increases from 1010 at 75° to 7200 at 200°, the flow is in the viscous zone at the inlet end of the heater and in the transitional zone at the outlet end. Hence Fig. 4 should be used to compute h_i.

$$N/D = \frac{16}{(0.902/12)} = 213$$

The ordinate is:

$$h(\beta/_t\ 0.53a) = h\left[\frac{(\mu_w)^{0.14}\,(b)^{0.53}}{(G)\,(C)^{1/3}\,(k)^{2/3}}\right](1/t^{0.53a})$$

$$= h\left[\frac{(4.5)^{0.14}\,(2.5\times 10^5)^{0.53}}{(3)\,(3600)\,(56.4)\,(0.52)^{1/3}(0.091)^{2/3}}\right](1/t^{1.06})$$

$$= h(0.009/t^{1.06}).$$

$$1/U_i = 0.00097 + 1h_i.$$

t°F.	75	80	100	110	120	140	160	180	200
Re	1010	1150	1800	2180	2590	3530	4610	5830	7200
$h(\beta\div t^{0.53a})$*	.0031	.0028	.0022	.0019	.0025	.0033	.0038	.0039	.0040
h_i	33.5	32.4	31.5	30.8	44.4	68.3	91.7	107	122
U_i	32.4	31.4	30.6	29.9	42.6	64.1	84.2	96.9	109.1
U_i**	32	31.5	30	29	42	64	82	96	108

*From Fig. 4.
**Values obtained by McAdams & Gilliland.

NOTE: The error introduced by this simplified calculation is well under the accuracy of reading Fig. 4. A graphical integration by plotting $1/U_i(T-t)$ versus t in this problem indicated a heating area of 990 sq. ft.

Unusual Crude from Old Ocean Field, Brazoria County, Texas

●

THE petroleum produced from the Old Ocean field, Brazoria County, Texas, is a rather unusual oil. A sample taken directly from a well by a U. S. Bureau of Mines engineer and analyzed by the Bureau's Hempel method was light in color and contained more than 70 percent of gasoline and naphtha. The crude oil is low in sulphur content and contains approximately 14 percent of kerosene distillate; the remainder of the oil likely would be graded as gas oil.

The analysis made at the Bureau of Mines Petroleum Experiment Station at Bartlesville, Oklahoma, is given herewith.

Old Ocean Field

9832-9964 ft.

Texas
Brazoria County

GENERAL CHARACTERISTICS

Specific gravity, 0.763
Sulphur percent, less than 0.1
Saybolt Universal viscosity at 77° F. less than 32 sec.
Saybolt Universal viscosity at 100° F. less than 32 sec.

A.P.I. gravity, 54.0°
Color, lighter than N.P.A. No. 1

DISTILLATION, BUREAU OF MINES HEMPEL METHOD

Dry distillation — Barometer, 733 mm. — First drop: 27° C. (81° F.)

Temperature, °C.	Percent cut	Sum, percent	Specific gravity of cut	°A.P.I. of cut	Viscosity at 100° F.	Cloud test, °F.	Temperature, °F.
Up to 50	2.7	2.7	0.633	92.0	.....	.....	Up to 122
50— 75	7.3	10.0	.671	79.4	.....	.....	122—167
75—100	15.3	25.3	.715	66.4	.....	.....	167—212
100—125	13.4	38.7	.743	58.9	.....	.....	212—257
125—150	14.3	53.0	.758	55.2	.....	.....	257—302
150—175	10.1	63.1	.775	51.1	.....	.....	302—347
175—200	8.3	71.4	.789	47.8	.....	.....	347—392
200—225	7.4	78.8	.804	44.5	.....	.....	392—437
225—250	6.5	85.3	.816	41.9	.....	.....	437—482
250—275	6.3	91.6	.830	39.0	.....	.....	482—527
Vacuum distillation at 40 mm.							
Up to 200	3.7	3.7	0.846	35.8	40	5	Up to 392
200—225	2.3	6.0	.849	35.2	47	30	392—437
225—250[1]	.....	.....	.....	.....	.....	.....	437—482
250—275	.....	.....	.....	.....	.....	.....	482—527
275—300	.....	.....	.....	.....	.....	.....	527—572

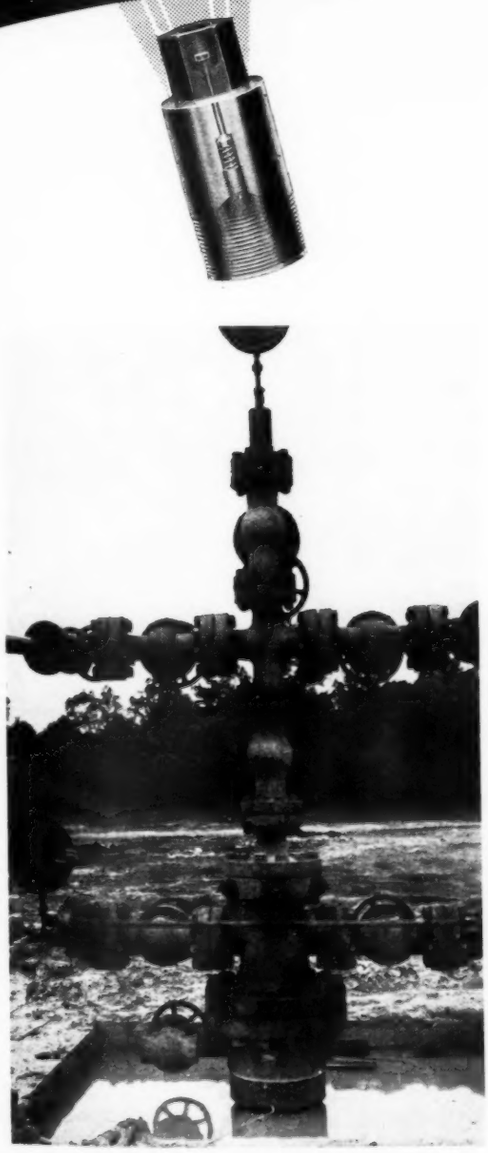
[1]Vacuum distillation discontinued at 225° C.
Carbon residue of residuum 0.1 percent; carbon residue of crude nil.

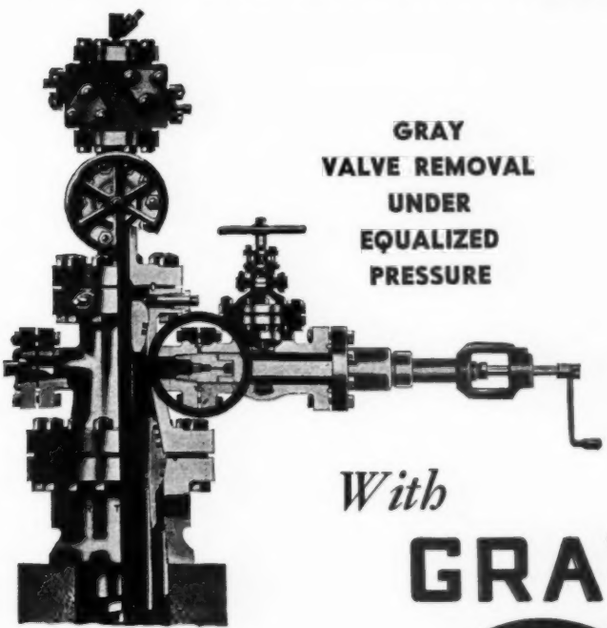
Approximate Summary

	Percent	Sp. gr.	°A.P.I.	Viscosity
Light gasoline	25.3	0.694	72.4	.....
Total gasoline and naphtha	71.4	0.738	60.2	.....
Kerosene distillate	13.9	.810	43.2	.....
Gas oil	12.3	.838	37.4	.....
Nonviscous lubricating distillate	....	....	....	50—100
Medium lubricating distillate	....	....	....	100—200
Viscous lubricating distillate	....	....	....	Above 200
Residuum	2.1	.877	29.9	.....
Distillation loss	0.3	....	....	.....

THE PLUG THAT PICKS OFF LOAFING Valves

AND PUTS THEM BACK TO WORK ON OTHER JOBS...





GRAY VALVE REMOVAL UNDER EQUALIZED PRESSURE

With

GRAY

YOU GET

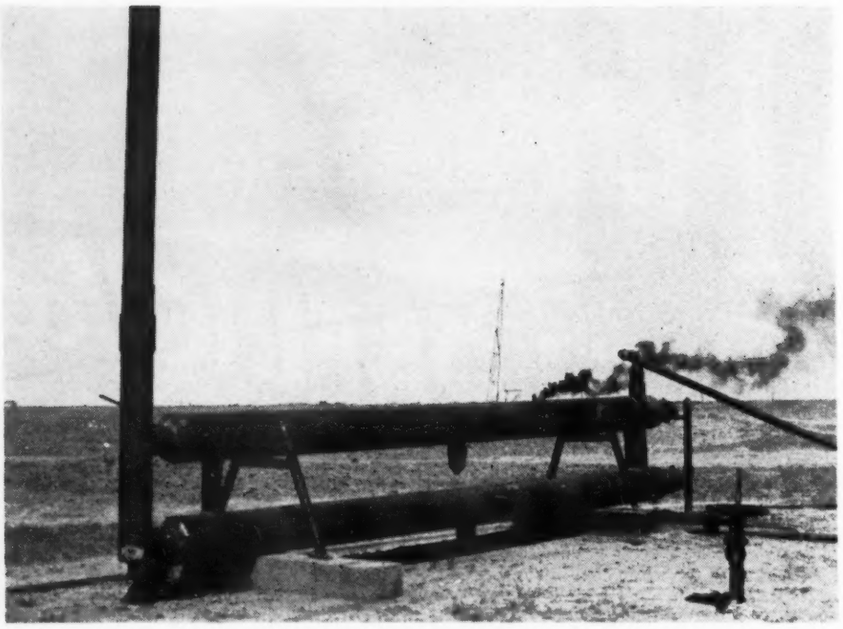
ECONOMY: Instead of valves and other equipment being left on wells to rust away, they are removed to perform their functions again on other wells.

GRAY

TOOL COMPANY

HOUSTON – TEXAS

P 546.34



Oil heating unit on lease at Altus, Oklahoma, of Gulf Oil Corporation, Gypsy Division

A PETROLEUM ENGINEER FEATURE

Small portable gas-fired unit installed in lead line between the tubinghead and flow tanks

Heater for Treating Cut Oil

By J. C. ALBRIGHT

BECAUSE some of the wells completed in the granite wash in Jackson County, Oklahoma, produce cut oil, several of the producing companies in that area have installed small, portable, easily-cleaned gas-fired heaters. The heaters are installed in the lead lines from the wells between the tubinghead and the flow tanks. They may be set to deliver a constant temperature when adjusted for a definite volume of fluid.

The accompanying illustration shows the general manner of fabricating these heaters. Two joints of 8-in. pipe form the main body of the heater. Inside each joint of 8-in., a joint of 4-in. pipe is centered and held in place by swaging and closing each end of the 8-in. The oil flows through the annular space between the 8-in. and the 4-in. pipe. Circulation from one 8-in. pipe to the other is provided by a short 4-in. nipple at the stack-end of the heater. The 8-in. pipes are separated at the other end by an 8-in. nipple tack-welded to the pipe surfaces.

The 4-in. pipe joints serve as combustion chambers and a heating medium. A section of 6-in. pipe, welded at one end of the heater as a stack, joins the two 4-in. and provides an outlet for the burned gases. A collar on the upper end permits a second section of 6-in. to be attached if the height is insufficient to obtain the necessary draft. A 4-in. collar closed by a bull-plug, is welded to the lower end of the stack to facilitate the removal of soot and scale when cleaning the apparatus.

Each section of the 8-in. pipe has a clean-out collar on the underside, closed by a bull-plug when in operation, but open when washing-out the accumulation of bottom sediment that may adhere to the inner surface of the heater.

The assembled unit is installed on concrete piers having pipe braces to maintain the unit in an upright position when in service. The open ends of the 4-in. joints contain burners having adjustable doors for controlling the draft. The unit is installed with the stack end pointing into the prevailing winds to prevent the fires being extinguished by strong gusts of wind.

The lead line from the well is connected to the lower 8-in. pipe at the burner end. Thus the oil travels toward the stack in the lower section and, passing through the 4-in. connecting nipple, flows back toward the burner end, and out through a 4-in. collar, to which is connected the line leading to the flow tank.

J. C. ALBRIGHT

after participation in the World War, was drilling superintendent for H. J. von Hagen in North Texas area, 1919-1921—With the Noble Oil and Gas Company, Burkburnett, Texas, in the natural gasoline and refining departments, from 1921 to 1923—Joined staff of the Dixie Gasoline Company in 1923 and became Texas manager—Employed by Phillips Petroleum Company in 1925 and was sent to New Mexico as special representative at Artesia where the company constructed a natural gasoline plant—Made state representative by that company in 1926—Left Phillips in 1929 and for a time operated as a consulting engineer, having offices at Brownwood, Texas—For last ten years has devoted practically all his time writing as a free lance for trade journals.

ANNOUNCEMENT

IN ORDER to more fully serve our customers in the oil fields, the BAROID SALES DEPARTMENT wishes to announce the acquisition of the Drilling Mud business of the Geo. S. Mepham Corporation and C. K. Williams & Company of California.

This will enable us to offer to the trade, in addition to the products previously handled by this company, the products formerly handled by the above mentioned companies. These products include COLOX, JELOX and "CHEMICAL Z", and they may be obtained in the various oil fields from the same distributors by whom they have previously been handled.

BAROID SALES DEPARTMENT

NATIONAL PIGMENTS & CHEMICAL DIVISION OF
NATIONAL LEAD COMPANY
BAROID SALES OFFICES • LOS ANGELES • TULSA • HOUSTON

LAUGH WITH BARNEY

An eminent judge at a banquet was offered champagne but refused it, saying he had tried it once but it didn't agree with him. Later, someone offered him a cigar.

"No, thanks," said the judge, "I smoked one once and didn't care for it."

An eminent lawyer nearby leaned over to his friend.

"You know," he whispered, "the the judge has only one child."

* * *

Mean Guy

Jones was sitting with his wife behind a palm on a hotel veranda late one night when a young man and a girl came and sat down on a bench near them. The young man began to tell the girl how pretty and good and lovable he thought she was.

Hidden behind the palm, Mrs. Jones whispered to her husband:

"Oh, John, he doesn't know we're here and he's going to propose. Whistle to warn him."

"What for?" said Jones. "Nobody whistled to warn me."

* * *

"What d'ya say, Jim, we get our wives together tonight and have a big time?"

"Okay by me, Sam, where'll we leave 'em?"

* * *

A college professor was calling the roll in one of his classes.

"Robinson."
"Here."
"Rosenthal."
"Here."
"Mary Smith."
"Present."
"Wanamaker."
"Hell, yes."

* * *

The doctor was examining school children. One youngster was under weight.

"You don't drink milk?"

"Nope."

"Live on a farm and don't drink milk at all?"

"Nope, we ain't hardly got enough for the hogs."

The members of an exclusive hunt club decided to hold a fox hunt and all participants were instructed to bring only male dogs. However, one very influential member owned only a female dog and she was allowed to run with the pack.

The day of the hunt the club members followed the dogs for nearly an hour and finally lost them completely. Coming across a farmer one of them asked, "Did you see a fox and a bunch of dogs go past here?"

"Yeah," said the farmer, "they went past here about five minutes ago going that way."

"They did," said the club member with interest, "how far ahead was the fox?"

"Ahead?" asked the farmer. "When they went by here the fox was in fifth place."

* * *

Your husband is in no great danger, Mrs. Murphy, but I'm afraid I'll have to anaesthetize him."

"Well, if you must, you must, but dear Mike did so want to have a boy."

* * *

A girl went out one evening with three brewery salesmen. When she got home she had a Blue Ribbon in her hair, Schlitz in her skirt, Budweiser!

* * *

"Please, suh," said a Negro servant to his employer, "I'd like tomorrow off, so's I can get married."

"Married!" exclaimed the boss. "Why, Sambo, it was only a month ago I gave you a day off to attend your wife's funeral. How can you think of getting married again when your first wife hasn't been dead a month?"

"Well, suh," confessed the widower, "I never was one to hold a grudge long."

* * *

Golf Club Lunch Menu

Scotch Broth
Club Sandwich Sliced Tomatoes
Link Sausage
Dandelion Green Puttatoes
Parsnips
Cup Custard
Rolls Nuts
Tea

"I don't feel right about Jim Smith!" Farmer Jones said to his wife. "He's just invited me to be a pall bearer again. He invited me to be a pall bearer when Mame, his first wife, died, an' he invited me again when Susie, his second wife, died. An' now his third wife's died an' he's invited me agin. It don't seem right for me to accept all them favors an' not do him any."

* * *

Bank Clerk: You forgot to dot an "i" in your signature.

Patron: Would you mind dotting it for me?

Clerk: I'm sorry, but it has to be in the same handwriting.

* * *

Another Version

Prof: Mr. Smith, will you tell me why you look at your time-piece so often?

Smith (suavely): Yes sir! I was afraid, sir, that you wouldn't have time to finish your interesting lecture, sir.—*Missouri Showme.*

* * *

Nowadays a son usually finishes college and his dad at the same time.

* * *

Why is it that ants are supposed to be the hardest workers in the world, yet have time to attend all the picnics?

* * *

Jane: I hear you were out golfing with Eddie. How does he use the wood?

Mildred: I wouldn't know. We played golf.

* * *

"What makes it jerk so when you first put it in gear?"

Car Salesman: Eagerness to get away, sir; nothing more, I assure you."

* * *

First Caddie: What's your man like, Skeeter?

Second Caddie: Left 'anded, and keeps 'is change in 'is right 'and pocket.

* * *

"I've got a perfect news story."

"The man bite a dog?"

"Naw, a bull threw a congressman."

A BLUE PRINT OF A SUCCESSFUL TOOL

THESE FEATURES ARE RESPONSIBLE FOR ITS SAFETY AND REMARKABLE PERFORMANCE:

1. Correct Design . . . engineered by experienced oil men.

2. Sturdy Construction . . . withstands use and ABUSE.

3. Positive Blade Opening and Closing . . . safety first and LAST.

4. Blades, Hard-Faced (Borium Inserted) . . . long cutting life.

5. Precision Machining . . . where accuracy counts.

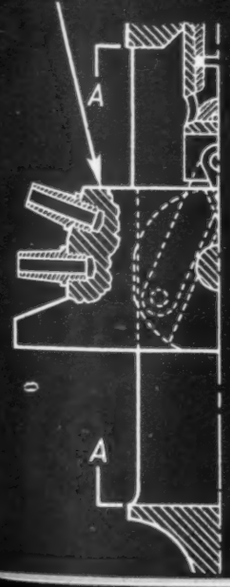
6. Alloy Steels that Stand Up . . . selected for performance.

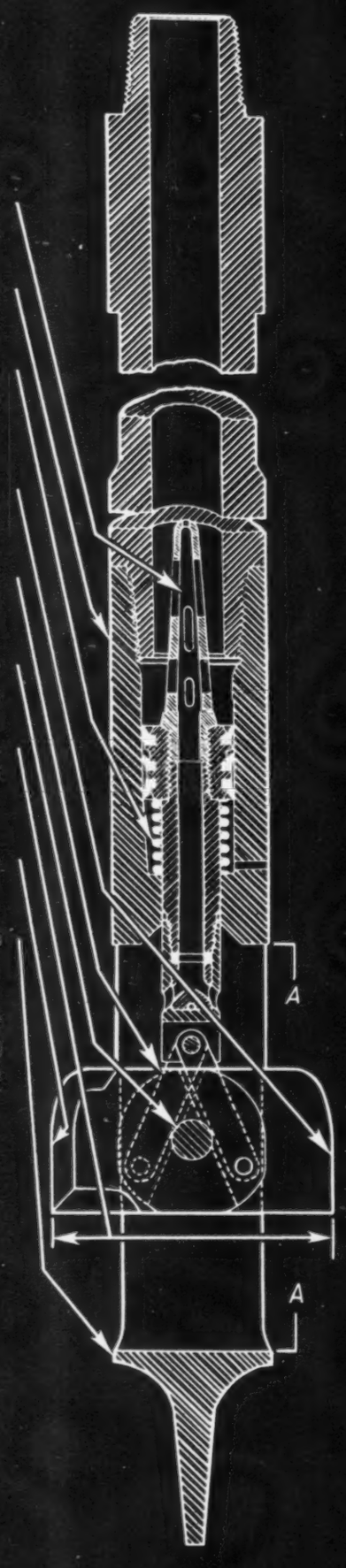
7. Remarkable Reaming Capacity . . . an expansion range of from 4" to 36".

8. Long Reaming Surface . . . no corkscrewing.

9. O. D. Same as Tool Joints . . . can't hang up.

10. Conversion into a Baker Wall Sampler by Changing Blades . . . This is an exclusive Baker Feature.





Success in oil field operations is measured by a single yard-stick . . . RESULTS and on this basis the Baker Rotary Wall Scraper has well earned, in thousands of runs made throughout the world, its claim to being a "successful tool."

EFFICIENT APPLICATIONS

Following are some of the efficient applications for the Baker Rotary Wall Scraper:

SETTING LINERS

SETTING CEMENT PLUGS

BOTTLE-NECKING FOR CEMENTING PURPOSES

ENLARGING HOLES FOR CASING

ENLARGING HOLES FOR GRAVEL PACKING

STRAIGHTENING HOLES

FISHING JOBS

WATER SHUT-OFF TESTS

TAKING CORES FROM SIDE WALLS OF PREVIOUSLY DRILLED HOLE . . . BY SUBSTITUTING SAMPLER BLADES FOR THE REGULAR SCRAPER BLADES

These and other efficient time and money saving applications are described in detail in the Baker Broadcast No. 19 (gladly sent upon request). Complete information will also be found in the Baker Section of the 1939 Composite Catalog.

BAKER OIL TOOLS, INC.
HUNTINGTON PARK, CALIFORNIA
HOUSTON, TEXAS

BAKER ROTARY WALL SCRAPER

Planned Lines Aid Mud System Cleanouts

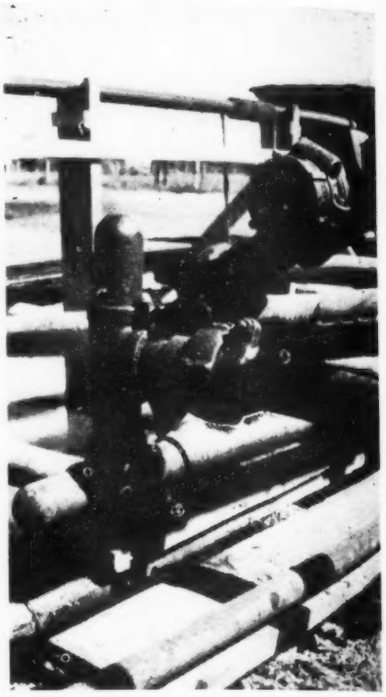
By

CHARLES C. LYNDE

SPECIFYING tees in place of ells in the piping of the mud systems on his drilling rigs, one Mid-Continent contractor insures a quick cleanout when occasional clogging occurs. At each turn in the line the open end of the run of the tee is blanked with a bull plug. Bull plugs are preferable to flat plugs because they provide a better hold for a wrench or tongs when the plug must be broken-out for cleaning the line. Tees in a line provide a fitting that is much stronger structurally than an ell. The flat top of a tee affords better purchase with a wrench or tongs in making-up or dismantling the mud piping.

It will be noted in the accompanying photograph that the bolted type of quick-acting union is also used to permit prompt removal of the clogged sections when necessary and to facilitate dismantling the system into lengths more easily transported when the rig is moved to a new location.

This is only one example of the benefit to be derived from a study of piping arrangements to obtain flexibility in modern hook-ups. The rigidity of an all-welded piping assembly particularly makes a liberal use of flanges, etc., advisable.



Tees having outboard runs closed by bull plugs provide quick cleanout facilities in event of mud-line stoppage

Acid Treatment of Kansas Oil Wells Increases Production

A STUDY of the effects of acid treatment of oil wells in the State of Kansas has been completed by the U. S. Bureau of Mines.

Almost every oil well drilled into limestone formations in Kansas is treated with hydrochloric (muriatic) acid upon completion. The wells are treated with acid to increase their potential capacities and thereby increase their "daily allowable" productions; to shorten the time required to produce the recoverable oil, and to increase the ultimate recovery of oil.

Acid treatment marked a forward step in the producing fields of Kansas; in fact, many old limestone fields that had almost reached their economic producing limit were "rejuvenated" with acid, and their capacities to produce increased several times. It also caused a marked increase in the ultimate oil recovery of some old and nearly depleted fields of Kansas. Stimulative effects of acid are ascribed to the "cleaning-out" action by the acid at the face of the limestone, the enlargement of small drainage channels, and to the penetration of the acid to previously undrained porous and saturated strata. Studies of the effects of acid were made in the Fairport field, three groups of wells in the Eldorado field, and in the Shutts field. Estimation of increased recoveries resulting from use of acid in the above fields and groups of wells ranged from 1000 to 2400 bbl. per acre.

Limestone structures that had been tested by drilling and found non-commercial were later developed as commercial oil-producing formations through the use of acid. The Kansas City formation in the Valley Center field of Kansas is an example of this type of reservoir.

The increased oil production and revenue from the old fields justified the reconditioning of equipment that in most wells had reached a stage of poor mechanical upkeep.

The first treatment with hydrochloric acid of an oil well in Kansas was in October, 1932. Treating programs were soon put into practice by various oil companies, and by the end of 1937, almost 6000 wells had been treated. Many wells were treated more than once, and the total number of treatments exceeded 8000 by the end of 1937. Approximately 12¾ million gal. of acid were required for these treatments.

This study by R. E. Heithecker has been published as Report of Investigations 3445, "Effects of Acid Treatment Upon the Ultimate Recovery of Oil from Some Limestone Fields of Kansas." Copies of the report are available without charge upon request from the Bureau of Mines, Washington, D.C.

Running Tour
WITH MEN IN THE INDUSTRY

R. A. BRUCE, drilling superintendent for Assam Oil Company, and Mrs. Bruce, who have been in Los Angeles, California, on a combined business and vacation trip, have returned to India.

L. L. RECTOR, of the Rector Well Equipment Company, Fort Worth, Texas, is making an extended trip through oil fields of Colorado, Wyoming, Montana, and to the Turner Valley field, Canada. He left his office June 28 and expects to be away about a month.

W. H. STUEVE has been made manager of the Department of Industrial Development of the Oklahoma Gas and Electric Company, Oklahoma City, Oklahoma. He will occupy this new position and continue to perform his former duties with the company.

A. PRANGER, chief engineer of The Guiberson Corporation, has returned to his office in Dallas, Texas, after a trip through the Rocky Mountain states during which he made a survey of general conditions in the Colorado, Wyoming, and Montana oil fields.

D. D. CLARK, warehouseman for Colombian Petroleum Company, has left California to return to Colombia. **D. W. PATTON,** driller for the same company, has also returned to Colombia.

S. F. SHAW will be in the Turner Valley field, Canada, for the next few weeks, and then will visit the Wilmington field, California, where the Westgate-Greenland Oil Company has a lease, for which company he is consulting engineer.

F. K. SPRAGINS, engineer, Carter Oil Company, has been transferred from Harrisburg, Illinois, to Carmi, Illinois.

W. B. SHARP, president of Mission Manufacturing Company, Houston, Texas, is spending the month of July in Mexico City.

H. C. RAMSEY, vice-president in charge of operations of Worthington Pump and Machinery Corporation, Harrison, New Jersey, has announced several promotions to key positions in the corporation's Harrison and Holyoke Works' staffs.

L. C. RICKETTS, a member of the Worthington organization for the last ten years, and recently general superintendent of the corporation's Harrison Works, has been appointed manager of that Works. **W. D. SIZER,** who joined Worthington in 1920, is appointed executive engineer in charge of all engineering activities at Harrison. **B. R. McBATH** now assumes full responsibility as engineer in charge of the centrifugal engineering division, succeeding **W. D. SIZER. J. H. BRAUTIGAM** succeeds **W. H. SCHERER** as manager of the corporation's Holyoke Works. This appointment returns Brautigam to Holyoke at which point he joined the organization in 1928, leaving there to assume his duties as assistant works manager of the Harrison plant in 1932. **W. H. SCHERER** will devote his entire time to the further development of manufacturing methods in all of the corporation's plants, as assistant to **H. C. RAMSEY,** having headquarters at Harrison.

REX WATSON, chief petroleum engineer, Lago Petroleum Corporation, Maracaibo, Venezuela, was a recent visitor in Los Angeles, California.

E. K. BURGHER, production superintendent for the Aguila of Mexico, recently left for home after a visit to Los Angeles, California.

FRANK S. O'NEIL has been appointed general manager of the Link-Belt Company's plants in Indianapolis, Indiana, of which he had been assistant general manager for the last seven years. O'Neil joined the Link-Belt organization 33 years ago at the company's Chicago plant, where he worked ten years in the foundry, machine shop, cost department, and rate setting and production departments. His Indianapolis plant experience dates back to 1916.

TRAJAN NITESCU, field superintendent for Concordia Oil Company, Gura Ocnetei (Dambovita), has completed a study of American-made equipment and on July 5 sailed from New York for Roumania. While in the United States Nitescu visited the Gulf Coast, Texas, and Mid-Continent fields and then went to California, where he visited the major operations, spending some time in Los Angeles for the purpose of inspecting the various manufacturing plants.

LELAND E. FISKE, oil and gas valuation engineer for the income tax unit of the U. S. Treasury Department, Washington, D. C., is being transferred from Washington to the office of the internal revenue agent in charge at Dallas, Texas, effective July 1. Eight additional oil and gas valuation engineers expect to be sent from Washington to various field offices about September 1. It is hoped that this "decentralization" policy, which embraces engineers and a number of auditors, will increase efficiency, expedite the closing of tax cases, and save the taxpayer the expense of trips to Washington to obtain agreement on minor tax matters.

LUKE E. SAWYER, formerly assistant general superintendent of The Babcock and Wilcox Tube Company, Beaver Falls, Pennsylvania, has been appointed general superintendent.

W. E. GRAY, general superintendent at Temblador for the Standard Oil Company of Venezuela, is in Los Angeles, California, for a short visit. He is accompanied by Mrs. Gray.

C. W. POTTER, who has been with Bahrein Petroleum Company and California Arabian Standard Oil Company, and who will return to one of the Arabian fields where he will be in charge of operations, entertained the Nomads of Los Angeles, California, with moving pictures showing native life in Arabia, India, the East Indies, and Hawaii. Potter is making a study of equipment and has been visiting the major operations in California.

E. P. COONRAD, of the production department of the Caribbean Petroleum Company, has returned to the Mene Grande field, Venezuela.

GORDON GRAY, tool pusher with Antilles Petroleum Company, Trinidad, is spending his vacation in Los Angeles, California.

M. T. MAGUIRE, manager Coupling Department, Bartlett Hayward Division, Koppers Company, manufacturers of Fast couplings, is back at his desk in the Baltimore office after a month's serious illness.

MARTIN GAMBAL, driller with United British Oilfields of Trinidad, left for the Island on July 10. He and Mrs. Gambal have been in Los Angeles, California, on vacation.

L. P. ST. CLAIR, past president and retiring chairman of the board of directors of the Union Oil Company of California, was honored recently with a dinner at the California Club, Los Angeles. Hosts were members of the Wildcat Committee of the California Oil and Gas Association. Guests were St. Clair's fellow members of the board of directors of the association. **J. R. PEMBERTON,** chairman of the Wildcat Committee, acted as toastmaster. As a token of respect and friendship, **FRANK A. MORGAN,** past chairman of the Wildcats, presented St. Clair with a silver cigarette box engraved with the signatures of all those present.

R. H. QUISENBERRY, O. H. BELL, and **W. H. WELLMERLING** have organized the Quisenberry Drilling and Production Company. Headquarters are in Bloomington, Illinois.

F. S. COURTER, acid engineer with Dowell Incorporated, has been transferred from Hobbs, New Mexico, to Allegan, Michigan.

P. F. ELMORE has been placed in charge of the Continental Oil Company's stabilization plant at Ville Platte, Louisiana. He has been in charge of the company's plant at Shiprock, New Mexico, and has been succeeded there by **R. L. HARPER.**

ROBERT W. COGHILL, who has been a consulting engineer making his headquarters in Houston, Texas, and prior to that was with the W. M. Kellogg Company, has joined the staff of the Cooper Petroleum Company, Houston, Texas. His new duties will embrace principally the making of crude oil contracts, both domestic and foreign.

R. H. MORRISON and **G. V. D. MARX,** Standard Oil Company of California men, were claimed by accidental death recently. Morrison's death was caused by an explosion at his house at Catalina Island. He had been with

R. H. MORRISON

the Standard and its subsidiary companies for many years. At one time he was manager of The California Company, a subsidiary, making his headquarters in Dallas, Texas. In 1936 he was made vice-president and a director of The California Texas Oil Company and the Bahrein Petroleum Company,

G. V. D. MARX

Ltd. These posts he resigned December 31, 1938, to re-enter the employ of the Standard Oil Company of California. At the time of his death he was on an extended sick leave. Marx, who has been in the employ of Standard since 1925 and who was assistant chief petroleum engineer at the time of his death, lost his life by drowning while attempting to save relatives who had overturned in a boat at Half Moon Bay.

F. W. FLOYD, formerly vice-president and manager of production for the Carter Oil Company, having headquarters in Tulsa, Oklahoma, has assumed his new duties in Venezuela as manager of production for the Standard Oil Company.

J. H. GIRDLER and **T. W. WHEELER,** geologists with the Phillips Petroleum Company, have resigned to form an exploration drilling company having headquarters at Houston, Texas.

T. J. DONOGHUE retired as executive vice-president of The Texas Company, Houston, Texas, effective July 1, and has been succeeded by **J. SAYLES LEACH,** vice-president. Donoghue joined the staff of The Texas Company in 1902 and previously had seen 18 years' service in Pennsylvania with the Standard Oil Company. Announcement also has been made of the retirement of **P. C. SCULLIN,** vice-president and general manager of the Indian Refining Company, subsidiary of The Texas Company, and of **G. L. NOBLE,** vice-president, The Texas Company.

BYRON MEREDITH, division production superintendent, Sinclair Prairie Oil Company, and **JOE EASON,** division clerk, have been transferred from Troup, Texas, to Houston. The company's division headquarters have been moved to the latter place.

EDWARD J. BULLOCK, vice-president in charge of purchasing and a director of the Standard Oil Company of Indiana, has retired after 50 years' service with the company. **JAMES F. HEWSON,** purchasing agent, becomes manager of purchases.

L. B. TAYLOR, engineer for the Gulf Oil Corporation, has been transferred from Great Bend, Kansas, to Wichita.

JOHN M. CLAYTON has joined the staff of the Seaboard Oil Company as geologist. He will be stationed at Dallas, Texas, to succeed **R. V. FORSYTH,** who has been transferred to Mattoon, Illinois. Clayton formerly was with the Gulf Oil Corporation at Corpus Christi, Texas.

DR. JOHN H. BEYNON, of the Anglo-Iranian Oil Company's research station at Sunbury-on-Thames, England, has been elected an associate of the Institute of Chemistry of Great Britain and Ireland.

KENNETH M. WILLSON, chief geologist, Mid-Continent Petroleum Corporation, has moved his headquarters from Tulsa, Oklahoma, to San Antonio, Texas.

L. R. ROBERTS has been appointed managing director of the Dee Oil Company, Ltd., Liverpool. He has been general manager.

DR. J. A. L. HENDERSON, consulting petroleum engineer and vice-president of the Maritime Oilfields, Ltd., and the New Brunswick Gas and Oilfields, Ltd., left England recently for Canada and the United States on business. He will be away from his office about six months.

A. K. MacEWAN has been elected to the board of directors of the British Burmah Petroleum Company to succeed **A. W. G. BLEECK,** resigned. The place on the board made vacant by the resignation of **E. SEABORN MARKS** has been filled by the appointment of **SIR PADANIJI GINWALA.**

E. L. TAYLOR has been transferred from Tulsa, Oklahoma, to Wichita, Kansas, by the Shell Oil Company. He will be assistant to the Kansas production division manager, **C. R. BICKEL.**

LUKE SIMS, president of Fields and Sims Company, Inc., has transferred his headquarters from Fort Worth, Texas, to Mount Vernon, Illinois.

R. C. FARLEY, engineer, has been transferred by the Ohio Oil Company from Henderson, Texas, to Jefferson, Texas.

JOSEPH K. McINTOSH, engineer, The Texas Company, is now making his headquarters at Amarillo, Texas, having been transferred from Port Arthur, Texas.

J. L. TRACY, superintendent, Homestead Oil and Gas Company, is now located at Fort Worth, Texas. He has been stationed at San Angelo, Texas.

W. R. KENNEDY, engineer for The Texas Company, has been transferred from Wichita Falls, Texas, to Nocona, Texas.

FELIX R. CORBELL, production superintendent in the Talco field for the Magnolia Petroleum Company, has been transferred to the Lea district, New Mexico, as superintendent. He succeeds **R. H. ALEXANDER,** who died recently. Corbell's headquarters will be at Lovington.

JOE LAWRENCE, engineer with the Halliburton Oil Well Cementing Company, has been transferred from Wichita, Kansas, to Great Bend, Kansas.

GUY MABEE, superintendent, J. E. Mabee, drilling contractor, is now making his headquarters at Effingham, Illinois, having moved from Vandalia.

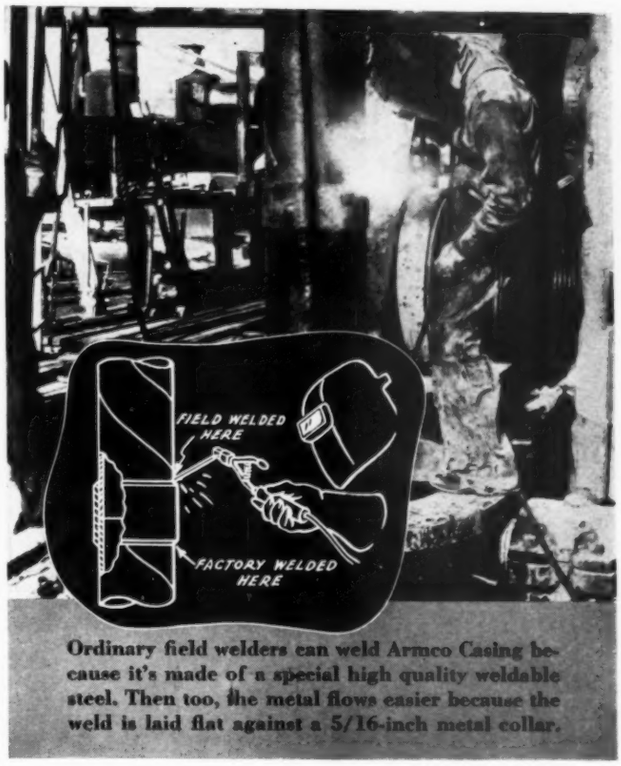
C. WOESSNER, engineer, Gulf Oil Corporation, New York Producing Division, has returned from an inspection trip to Venezuela.

J. E. HELLINGHAUSEN, Tulsa, Oklahoma, a recent graduate of the University of Tulsa, has joined the staff of Murchison and Fikes, Dallas, Texas, as a petroleum engineer. He is stationed at Allred, Yoakum County, Texas.

B. H. GRAY has acquired the Princeton, Louisiana, refinery of Lake Price Refineries, Inc., and will place it in operation under the name of the Pennant Refining Company.

YOU GET A TIGHTER JOINT

AT LESS EXPENSE



Ordinary field welders can weld Armco Casing because it's made of a special high quality weldable steel. Then too, the metal flows easier because the weld is laid flat against a 5/16-inch metal collar.

• Thrifty oil men everywhere are discovering that Armco Slip-Joint Casing is a real money-saver for conductor lines that are cemented in and never pulled.

One big reason is that Armco Casing eliminates the unnecessary expense of threaded ends. This saves you $29 a joint on 13⅜-inch, 48-pound pipe—a total saving of $580 in 600 feet, which more than offsets the cost of field welding. Besides, the field-welded slip joint gives you a tight, leak-proof connection with plenty of strength to withstand the conditions met in surface strings.

You'll also find Armco Casing easier to handle and set because it's free of excess weight. No special slips or elevators are required and each length lines up accurately in the slip-joint collar without need for special clamps. For immediate delivery of Armco Casing in standard sizes, just call the nearest store of our distributor, or address: The American Rolling Mill Co., Pipe Sales Division, Middletown, Ohio: 538 Mayo Bldg., Tulsa, Okla.; 3500 Maury St., Houston, Texas.

ARMCO

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NATIONAL TANK COMPANY

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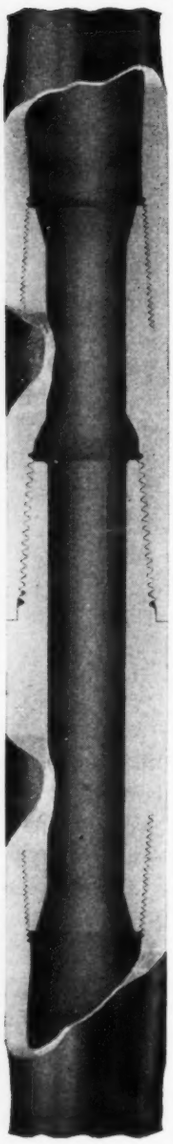
MACHINERY and EQUIPMENT

Reed Double Streamline Tool Joints



THE Reed Double Streamline Tool Joint has been developed for economical slim-hole drilling and for drilling with controlled circulation.

The Reed Double Streamline Drill Pipe is made with a gradually tapering external upset (5 deg.), and the double streamline tool joint is flush with this upset. Double streamline drill pipe has greater fluid capacity and more velocity in returns with less pump pressure than internal flush tool joints of the same outside diameter, the manufacturer states. There are no shoulders to wear away in the circulating flow stream or to obstruct the free flow of the bit cuttings, a condition that contributes to the building of a uniform mud-cake and maintaining it with the least disturbance, it is pointed out.

Write to the Reed Roller Bit Company, Houston, Texas, for catalog No. 0386.

Corrosion Preventer

RECTOR Well Equipment Company, Fort Worth, Texas, recently completed a series of exhaustive tests on a new product known as "Rectorkote, The Positive Corrosion Preventer." This new product, which is a modification of Rectorseal, has proved successful in combating various types of corrision prevalent in the oil industry, the manufacturer states.

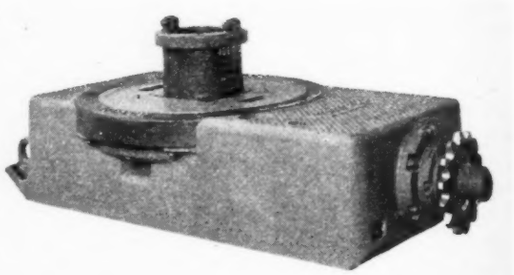
Rectorkote has been used to prevent inside corrosion of steel tanks in "sour crude" fields, on tank bottoms to retard salt water corrosion, on the inside of pipe utilized in salt water disposal, on the outside of pipe lines laid through salty marshes, and inside wood and steel treating tanks. It also retards, and in some cases prevents, paraffin deposits on the walls of tubing, according to the makers.

All ingredients of Rectorkote are insoluble in petroleum and its products, and also in salt water and dilute acids. The product is applied with a spray gun, and a special type of gun is available to produce a uniform coating of Rectorkote on the inside of pipe lines.

Rector Well Equipment Company will be glad to consult with any operators having corrosion problems, and will supply, on request, complete information concerning Rectorkote.

Ideco 17¼-in. Oilbath Rotary

IN constructing the new Ideco 17¼-in. "Streamlined" Oilbath Rotary, chrome-nickel, heat-treated steel is used throughout, the sturdy, box-like, one-piece construction of the bed fits conveniently into the derrick base sills and floor, and the flat rectangular top with its non-skid surface is convenient and safe for the workmen, it is asserted by the manufacturer.



The gear table also is a one-piece, heat-treated, chrome-nickel steel casting that provides a full 17-in. unobstructed opening.

The main bearings are 3-in. balls operating in hardened forged-steel races constructed to resist both vertical and radial loads.

Both the pinion and ring gear are of heat-treated alloy-steel, hammer-forged, having machine-cut teeth.

The table lock is placed on the machine opposite the sprocket in plain view of the driller. The lock engages the table directly, thus removing all strains from the pinion shaft bearings and gear teeth. A positive means is provided to safeguard accidental engagement or disengagement of the table lock.

The main bearing, hold-down, gears, and pinion bearings are all lubricated by one oilbath system. The reservoir is filled and gauged at one point on the top of the rotary. The pinion dips into the oil, circulates it to the ring gear, which throws the oil on the main bearing and hold-down. The oil then flows back into the pinion reservoir to be recirculated. Oil from the pinion reservoir also circulates to the pinion bearings, keeping the proper amount of oil in the pinion-bearing capsule at all times.

The simplicity of this design, resulting in very few parts, requires only 12 bolts and 12 cap screws for the entire assembly.

The accompanying illustration of this rotary shows an "Ideco" Roller Kelly Drive installed in the machine; however, this item is an accessory and not standard equipment.

The International Derrick and Equipment Company of Texas, Beaumont, Texas, is the manufacturer.

Type 38 Casinghead by "Oilwell"

OIL WELL SUPPLY COMPANY, Dallas, Texas, has developed a new, inexpensive casinghead featuring several improvements. It is of octagonal shape having straight sides for convenience in making-up with tongs. Compact construction provides low

overall height. Eight set screws apply uniform pressure and aid in keeping the packing tight.

The "Oilwell" Type 38 Casinghead is supplied in both semi-steel and cast-steel. Working pressures as high as 800 and 1600 lb. per sq. in. are permissible for the semi-steel and cast-steel heads, respectively, (provided the load on the tubing hanger is sufficient to prevent leakage at the packing).

The Type 38 Casinghead will receive any tubing hanger designed for use with a Berry pattern head, but is especially recommended for combination with the "Oilwell" Type 36 Tubing Hanger, as illustrated.

A three-segment, hardened-steel slip assembly in the Type 36 Tubing Hanger holds the tubing securely and without crushing. A spring encircling the three segments assures proper contact with the tubing before the taper of the slips and the bowl-shaped slip body become operative. The slip body rests on the packing element and utilizes the weight of the tubing string for compressing the packing.

The packing element is designed for both effective sealing and convenience of installation. It consists of top and bottom steel rings, split in halves, and a one-piece rubber ring, split diagonally.

The Type 36 Tubing Hanger is described in "Oilwell" Bulletin No. 166. Bulletin No. 196 covers the Type 38 Casinghead.

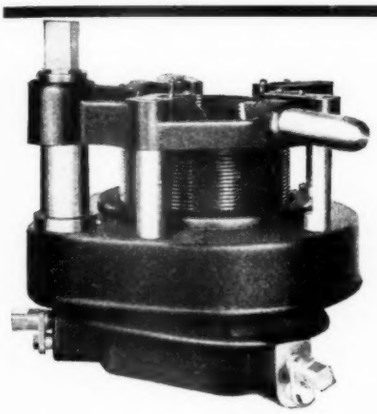
Drawworks, Mud Pump, and Table Motors

A COMPLETE line of wound-rotor a-c. drawworks, mud pump, and table motors for oil-well drilling is announced by the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania.

Of special interest in this new design are a protected collector assembly having liberal spacing of collector rings, liberal heat-radiating surface, and a construction of enclosed rings and leads to withstand high operating temperatures. These motors may be equipped with thermoguard to give protection against unsafe motor winding temperatures when motors are overloaded.

The standard line includes motors having gas-protected collectors and frames of open-type construction or splashproof construction that may be arranged with or for forced ventilation. Other features include rigid cast frame and end brackets, sealed-sleeve bearings, large conduit boxes, and Tuffernell insulation.

Motors of the new design, with control of the open or protected, manual or magnetic type, are available in ratings of from 50 to 500 hp., 3-phase, 50-60 cycles.



WHEN IT'S 2½" TO 4" PIPE CALL ON A "TOLEDO" No. 2BR

The "TOLEDO" No. 2BR is a favorite in the field—a separate set of dies for each size pipe assures easy operation and smooth, standard taper threads.

No bushings are used. An adjustable rear guide using three broad-faced jaws with size-marked guide bars and operated by heavy set screws makes for easy, accurate centering. A large gripping surface makes for good threads straight on the pipe. A minimum number of moving parts—hence long life.

Specify a "TOLEDO" No. 2BR 2½" to 4" threader and learn the difference. Sold by leading Dealers.

Three Broad Faced Chuck Jaws Are Easy to Center.

THE TOLEDO PIPE THREADING MACHINE CO.
TOLEDO, OHIO ***New York Office, 72 Lafayette St.***

"TOLEDO"
TRADE-MARK REGISTERED

YOU'LL DO BETTER WITH A "TOLEDO"

Penberthy Liquid-Level Gauge

A NEW drop-forged steel reflex liquid-level gauge has been placed on the market by the Penberthy Injector Company, Detroit, Michigan. The gauge is made in two types. Type S is recommended for pressures of 1500 lb. per sq. in. at a temperature of 100° F. and 500-lb. pressure at 1000° F.; Type V is recommended for 3000-lb. pressure at 100° F. and 1000 lb. at 1000° F. Gauges can be supplied in any required length.

Features of the equipment, as enumerated by the manufacturer, are:

(1) The gasket gland is machined integral with the liquid chamber and fits snugly into the glass chamber of the frame, preventing gasket blowout.

(2) The liquid chamber is of temperature-resisting alloy steel, heat-treated, accurately machined and ground. The multiple sections are made in one piece.

3. The gaskets are interchangeable and provide adequate and equal resilience on both sides of the glass.

(4) The glass chamber is frame-machined to the contour of the glass, providing a full metal backing for the gaskets.

(5) The frame of the gauge is of drop-forged, temperature-resisting alloy steel and has an especially heavy beam at each end.

Cast-Iron Domes for Wooden Tanks

BLACK, Sivalls and Bryson, Inc., Oklahoma City, Oklahoma, announce a new cast-iron dome for wooden tanks, shown in the accompanying

illustration. The dome has one to four 4-in. connections in the neck, high above the water line. There are no lines to take down when the dome cover is removed, as the new style dome does not have a connection through the cover.

DRILLING BURNERS

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Again proved by actual meter readings . . . .

John Zink Vertical Bi-Mix Burners installed in drilling boilers in West Texas show a 30% saving in fuel.

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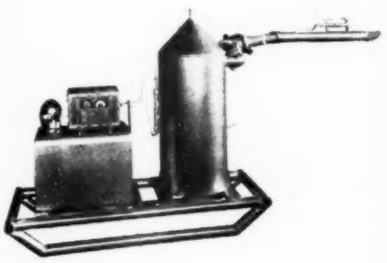
Equipment for Detecting Oil and Gas

THE Mid-Continent Supply Company, Fort Worth, Texas, has recently introduced two new pieces of equipment, the Mid-Continent Gas Detector and the Mid-Continent Fluoroscope, to give reliable and immediate information regarding the absence or presence of gas and oil in the formation being drilled. In addition to serving as positive, instantaneous detectors of gas and oil, these instruments permit more accurate logging and are valuable aids in subsurface mapping, the manufacturer states.

Mid-Continent Fluoroscope

The Gas Detector is connected directly to the rig and is fed by diverting



Mid-Continent Gas Detector

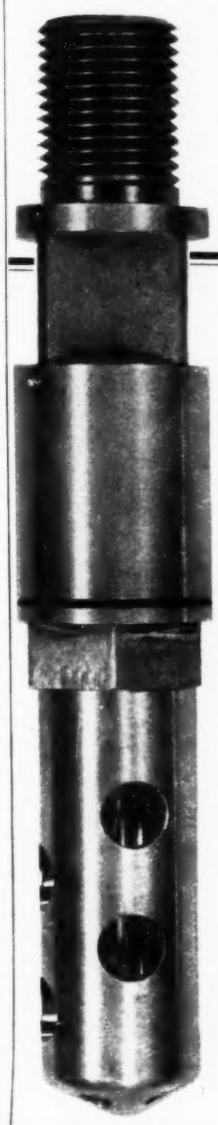
through the separator tank on the instrument a stream of mud from the flow line on its way to the slush pit. Baffles in the tank break-out any minute gas bubbles that may be present in the mud and the gas rises to the top of the tank where it is mixed with air. This mixture is then carried by suction to the electrical combustion detector, which immediately closes a contact and sounds the siren when the air contains a mixture of 2 percent gas or more. Although 2 percent is the weakest concentration that has been found effective, the detector can be set for any amount of gas so that if the circulating mud contains a definite ratio of mud and gas and it is the desire of the operator to be warned when this gas ratio increases, or when gas sands are penetrated, adjustment can be made to meet these requirements.

The Mid-Continent Fluoroscope is for the detection of oil only and operates on the principle of fluorescence observation. When petroleum, even in a very weak solution, is placed under a light of certain frequency, it will give off a ray of a different frequency, and it is these rays that are observed by the operator in looking at a mud sample when oil is present. The light causes the oil in the mud sample to fluoresce with a yellowish glow. When it is observed that an oil sand has been penetrated, the exact depth at which the formation was penetrated can be determined by computing the pump displacement of the well bore for time lag. If a change in formation is noticed by progress of bit, it is easy enough to drill into this formation several feet, then "free circulate" until the mud returns to the surface, and test the mud before drilling ahead. In this way, the amount of drill stem in the hole is used as the measurement to establish the depth of the formation.

As the Fluoroscope shows only oil fluorescence and does not show gas formation, no confusion can result.

Mid-Continent Supply Company are owners, manufacturers, and exclusive distributors of these instruments. Inquiries should be addressed to the home office at Fort Worth, Texas.

Get the *Cold Facts* *on Hot Formations*



with this Martin-Decker Recording Thermometer

Take a look at this instrument. Notice how compact it is. Yet, on just one trip into the hole, it gives a complete temperature record of your well from top to bottom—a chart record you can use *and then file away for future reference!*

It has a new type recording device—a radium-tipped dial that acts on a sensitized chart to make the record. It's friction-free—a distinct advantage over pen charts—and there are no bulky batteries or wires to monkey with as in other sensitized chart systems. Best of all, the instrument is accurate to within one *half* degree!

You can run it on an ordinary measuring line and it's small enough to go inside 1½ in. tubing, so you don't have to pull your well to get the cold facts on your well temperatures.

The Martin-Decker Radium Recording Thermometer comes in two sizes—1½ in. and 1¼ in. The big size uses circular charts, the small one uses strip type charts, and both record temperatures up to 300°F. Write for complete dope!

HOME OF THE WEIGHT INDICATOR

MARTIN DECKER CORP.

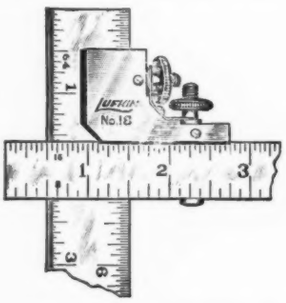
LONG BEACH, CALIFORNIA

SAN JOAQUIN VALLEY: A. F. McQUISTON, BAKERSFIELD, CALIFORNIA
MID-CONTINENT DISTRIBUTOR: REED ROLLER BIT COMPANY, HOUSTON, TEXAS

Right-Angle Rule Clamp

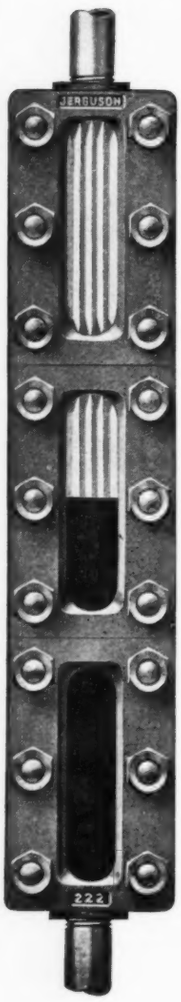
ANOTHER improved item recently added to the line of precision tools made by The Lufkin Rule Company, Saginaw, Michigan, is the right-angle rule clamp. It will firmly hold at right angles a combination square blade (of 12-, 18-, or 24-in. length) and any regular steel rule not more than 1 in. wide. So combined and employed with the heads of a combination square, it has many valuable applications and uses, the makers state. This clamp can also be applied to thin steel squares.

The clip provided with prongs at each end, as illustrated, is a feature of the Lufkin Rule Clamp. These prongs hold both clamp nuts in place. Thus interference of the two bolts and nuts is eliminated. Thumb nuts of this



right-angle rule clamp No. 18-A are knurled for good grip and of size most convenient to operate.

JERGUSON



REFLEX GAGES

are preferred by the Oil Industry because of their reputation for maximum efficiency at all temperatures and pressures.

Easy to read because the . . .

EMPTY SPACE SHOWS
WHITE

LIQUID LEVEL APPEARS
BLACK

Ideal for tanks, towers, stills, etc., carrying gasoline, kerosene, oil, no matter what the color of the liquid. Furnished with or without valves for every type of service.

When you need to show the color and density of liquids, use Jerguson Transparent (thru vision) Gages.

Jerguson Gages are Best
By every real test.

Write for Catalog.

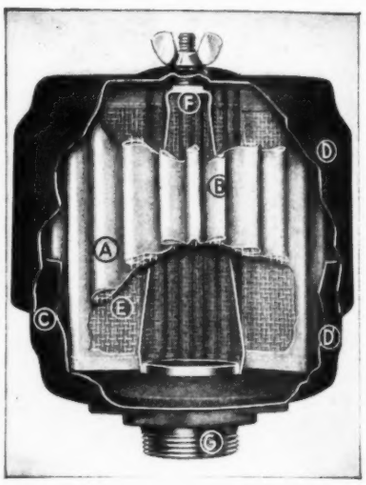
JERGUSON GAGE & VALVE CO.
89 FELLSWAY
SOMERVILLE MASSACHUSETTS

Air Filter For Small Engines

EMBODYING all the well-known Protectomotor principles, a newly designed dry-type air filter is being manufactured by the Staynew Filter Corporation, Rochester, New York, for small internal combustion engines, compressors, pumps, and all "air-breathing" machines.

As shown in the accompanying illustration, the Protectometer Model E is amply protected against all weather conditions by the heavily enameled steel housing. In the cut-away illustration, "A" indicates the exclusive, patented Radial Fin Construction that, according to the manufacturer, provides the largest possible filtering area in the smallest possible space. This means free air flow and long periods of operation without cleaning.

The dry Feltex filtering medium, also an exclusive Protectomotor feature, is indicated by "B". Feltex is a



felt-like material of extreme fineness, which permits free air flow, yet retards the smallest particles of air-borne matter. At "C" is shown the intake, approximately double the outlet area, thus keeping friction and turbulence of the entering air at a minimum. The weatherproof housing is shown as "D" and "D¹".

Note the heavy wire mesh backing of the filter insert at "E", and the Yoke, "F", both of which add to the rigid, vibration-resistant qualities of this filter, according to the makers.

The upper shell, "D", may be quickly removed and the insert lifted out for cleaning by merely unscrewing the top wing-nut. A threaded flange, "G", is provided by means of which the entire unit may be easily removed or installed. Both upright and hanging models are available in capacities ranging from 3 c.f.m. to 225 c.f.m. and in a wide selection of standard pipe sizes.

Lane-Wells Company Reorganizes

The officers and directors of Lane-Wells Company, reading from left to right: M. E. Montrose, director and general sales manager; D. S. Jeppson, director and controller; Rodney S. Durkee, president; Walter T. Wells, chairman of the board; Norman L. Dorn, vice-president and chief engineer; B. G. Peters, secretary-treasurer.

Final moves completing the reorganization of Lane-Wells Company were announced July 5th at the regular meeting of the board of directors. Rodney S. Durkee, who has been serving as executive vice-president, becomes president. Walter T. Wells, president and one of the founders of the company, becomes chairman of the board. Norman L. Dorn, chief engineer, becomes vice-president, and M. E. Montrose, general sales manager, D. S. Jeppson, controller, and B. G. Peters, secretary-treasurer, complete the directorate.

Commenting on the reallocation of duties, Durkee said, "Since the sale by Wells and Lane of the major portion of their holdings to the public early last year, numerous changes have been made with the idea of strengthening the organization, and wherever possible improving to the last degree the character of service rendered to the oil industry. It is felt that this latest move will enable us successfully to carry out the progressive and far-reaching program upon which the Lane-Wells Company embarked several years ago."

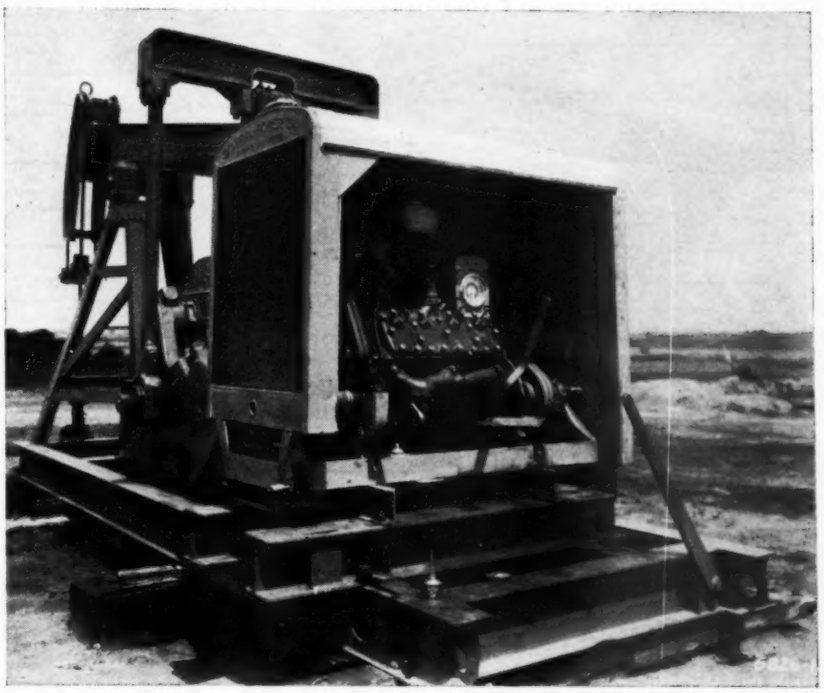
Founded seven years ago by Walter T. Wells and W. G. Lane, the Lane-Wells Company has expanded steadily until today its services are available throughout all oil fields of the United States and some foreign countries. Originally major emphasis was placed upon the gun-perforating service offered to oil well operators. With the acquisition of the Alexander Anderson Company, Inc., directional drilling and well survey service were added to the line. More recently, electrical open hole logging known to the trade as Electrolog, has developed into another major interest of the company. In addition to its engineering services to the oil industry, Lane-Wells Company also manufactures and sells a complete line of packers and liner hangers.

Gillespie Promoted

Air Reduction Sales Company, New York City, New York, announces the appointment of J. T. Gillespie, Jr., as assistant to Thomas B. Hasler, president of the Wilson Welder and Metals Co., Inc., an affiliate of Airco.

Gillespie has been assistant manager of the Central Division of Railroad Sales of Air Reduction Sales Company in Chicago. His new duties will be promotional sales activities in coöperation with I. B. Yates, general sales manager.

LOW INITIAL COST.....



Small Operating Cost

NOTE: The sturdy, compact appearance of this unit, and the simplicity of the installation.

General Units are establishing outstanding records for low operating costs in oil field Drilling, Pumping, and Generating installations. Engine and engine parts exchange plan assures minimum upkeep records.

The SEVEN models of General Power Ford V-8 Conversion Units are available with FOUR sizes of engines, FORD V-8, 60 h.p., 85 h.p., 95 h.p., and Lincoln-Zephyr. These Units are available in SINGLE, DUAL, and MULTIPLE engines for drilling, pumping, and generating installations.

Write for Complete Catalog

GENERAL POWER, Inc.

Quapaw, Oklahoma Phone 64

"Dan" Daniels, One of Industry's Old Timers, Passes Away

Another of the oil industry's old timers passed on with the death on June 26th of "Dan" Daniels at his home in Santa Monica, California. Daniels, or "Danny" as he was known to his many friends in the oil industry, died at the age of 75 years after a five months' illness.

He was born at Middlesborough, England, December 15, 1864. At the age of 12 he came to the United States and became apprenticed as an iron worker at the Baldwin Locomotive Works, in Lima, Ohio. In 1898, Daniels went to California as head of the Bakersfield Iron Works. In 1901 he organized what was to become the D. & B. Pump and Supply Company.

Daniels made notable contributions to oil-well pumping science.

After Daniels' retirement from active business in 1927, he devoted himself to philanthropic efforts and to the preservation of California landmarks and wild life.

At no Extra Cost...

Better - Safer
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More Service
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Ready to Install
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Saves Time
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Saves Labor
•
Saves Money
•
Eliminates Trouble

No more field brake-relining jobs with costly delays removing old lining and fitting on new—*Buy The Complete Unit.* Turn in your old worn and warped bands and receive Grizzly Full-Moulded Brake Blocks, installed on bands formed to correct curvature and shape—at *No Extra Cost*—all ready to place on your rotary rig. Insures getting the correct lining for the job; saves field installation; saves time all around; saves labor and money. The Grizzly Brake Block Band Exchange Plan assures you better, safer brakes and more ton miles of service under all operating conditions. It costs no more than you ordinarily would pay for lining and installation alone. Ask your supply house for further details.

E. M. SMITH COMPANY
600-650 South Clarence St., Los Angeles, California, U. S. A.
Complete Stocks Maintained in Our Warehouses at: 1121 Rothwell St., Section 16, Houston, Texas. 1008 S.E. 29th St., Oklahoma City, Okla. *Export Office:* Continental Emsco Co., 30 Rockefeller Plaza, New York City.
Distributed by Leading Supply Companies

GRIZZLY BRAKE BLOCK BAND EXCHANGE

New BJ Elliott Personnel

After acquisition by Byron Jackson Company of the Elliott Core Drilling Company, certain changes and additions have been made for improved sales and service facilities of the Elliott

GEO. JACOBS

Wire Line Retractable Core Drill and Drilling Assembly, the Elliott Model A Combination Rotary Core Drill, and other products previously marketed by the Elliott organization.

J. D. HICKS

J. E. (Brick) Elliott, Reid B. Grainger, and George Jacobs are continuing their association with Elliott products through the BJ Elliott Division of Byron Jackson Company in the Gulf Coast, and J. D. (Joe) Hicks, previously of the drilling contracting firm of Robinson and Hicks, has been

added to the staff as sales representative.

Houston Oil Field Material Company and Wilson Supply Company will

REID GRAINGER

act as Gulf Coast distributors. California sales and service will be handled by Pacific Cementing Company.

J. E. ELLIOTT

John H. Baird, 808 Graybar Building, 420 Lexington Avenue, New York, New York, will continue to serve as export representative.

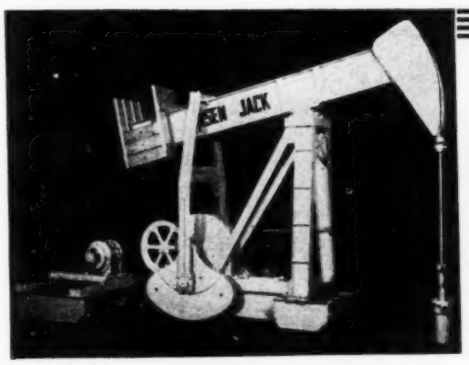
Controlling Hardness and Ductility of Steel Slush Pump Liners

A NEW and exclusive process of controlling the hardness and ductility of seamless steel slush pump liners is announced by the Harrisburg Steel Corporation, Harrisburg, Pennsylvania. The process was developed at the Harrisburg plant by Dr. T. Holland Nelson, noted metallurgist, and is known as the Nelsonizing Process.

Harrisburg liners thus processed possess maximum hardness and wear resistance where it is most desired, yet this hardness is backed up with material in a softer and more ductile condition and there is no sharp line of demarcation between the two, the manufacturer states.

"The outstanding features of this pump liner," said Dr. Nelson, "are that for almost any desired depth the inner surface can be raised to a Brinell hardness as high as 625, yet the outer surface, for any predetermined depth, can be maintained with a Brinell hardness of from 200 to 250."

Patent for the process has been applied for and assigned to Harrisburg Steel Corporation.



SIT TIGHT and MAKE MONEY

As long as supply and demand govern crude prices, the producer who straddles his wells with JENSEN Units can sit tight and make money.

You can't match the economy and efficiency of JENSEN Units because we've studied production problems for 20 years without a day's diversion. Pumping equipment is no side line with us. We've seen leases abandoned that could be produced profitably with JENSEN Units.

If you aren't satisfied with the way your wells are doing, wire us at Coffeyville. Our new Model D was made for men like you.

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. . . . . Coffeyville, Kansas

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• For lower power consumption, better appearance, less lubrication, minimum maintenance expense — standardize on the Link-Belt line of anti-friction bearings in modern streamlined mountings.

Send for a copy of catalog covering the complete Link-Belt power transmission line —bearings, take-ups, clutches, shafting, collars, gears, couplings, etc.

Link-Belt Company, Chicago, Dallas, Houston, Los Angeles, New York, or any of our other offices, located in principal cities.

7422-A

LINK-BELT Anti-friction BEARINGS

KINK OF THE MONTH
"in the interests of more efficient cleaning"

REMOVING SCALE FROM WATER COOLED EQUIPMENT
Now Easy

Circulating a solution of Oakite Compound No. 32 through the water side of water cooled equipment, followed by a plain water rinse, is all that is needed to remove every trace of scale and rust. And . . . the method is SAFE, as well as easy. Booklet giving details FREE on request.

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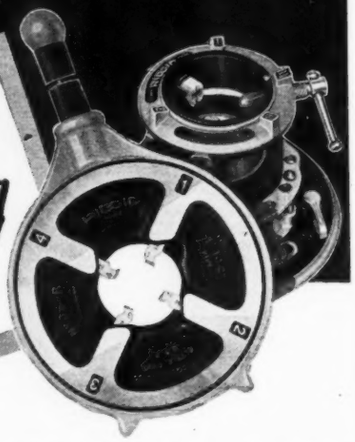
OAKITE 1909 1939 COMPLETING 30 YEARS OF SERVICE TO INDUSTRY

OAKITE *Certified* CLEANING
MATERIALS & METHODS FOR EVERY CLEANING REQUIREMENT

NEW RIDGID No. 65Rs

rid you of threading troubles



SELF-CONTAINED threaders, nothing to lose—no bushings; your choice of 2 speedy mistake-proof workholders, practically automatic. One set of chaser dies threads 4 sizes of pipe, 1″ to 2″—no extra dies to lug around or lose. Powerful new all-steel malleable-alloy construction. Faster, easier, lower cost threading—ask your Supply House.

THE RIDGE TOOL COMPANY, ELYRIA, OHIO

FAMOUS RIDGID PIPE WRENCHES
CUTTERS • THREADERS • VISES • EXTRACTORS

Emco Executives Take to Air

Pictured here are George Gleeson, sales manager Water Meter Division, Captain A. E. Higgins, vice-president in charge of sales, and Colonel W. F. Rockwell, president, all of the Pittsburgh Equitable Meter Company. They are about to enter Captain Higgins' plane on the first leg of a flying business trip that, with many stop-overs and side jaunts, will take the ship from coast to coast.

Parkersburg Absorbs Smith Separators

R. S. McKEEVER

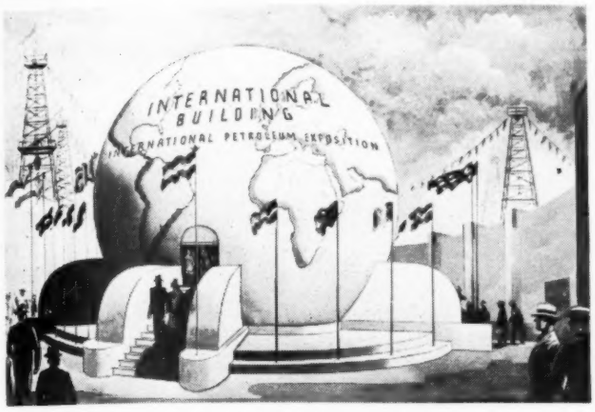
The Parkersburg Rig and Reel Company, which heretofore has been acting as exclusive distributor of products of the Smith Separator Corporation, Tulsa, Oklahoma, recently absorbed all rights to and interests in the Smith Separator and other products manufactured by the Smith Separator Corporation. Further plans call for Parkersburg to continue manufacturing their newly acquired line in Tulsa and to market it under the trade name of "Parkersburg-Smith."

R. S. McKeever, formerly president of the Smith Separator Corporation, and E. H. Ross, also formerly employed by that company, have joined The Parkersburg Rig and Reel Company and will be actively engaged in the selling of Parkersburg's newly acquired line of "Parkersburg-Smith Separators." Both McKeever and Ross will reside and work in Tulsa.

J. H. Smyth, formerly employed as an engineer by the Smith Separator Corporation, has also joined the Parkersburg organization and will reside in Tulsa and continue to be engaged in the designing of Parkersburg-Smith Separators.

Contracts for 1940 Oil Show Mailed

Contracts for reservation of exhibit space for the May 18 to 25, 1940, International Petroleum Exposition have been mailed to 1938 exhibitors, who are given options on their space until August 15 of this year, according to General Manager Wm. B. Way.



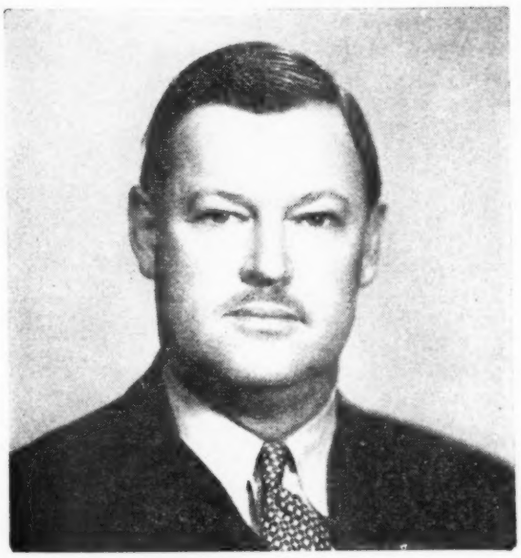
Architect's conception of the International Building planned for the International Petroleum Exposition

Space rates, rules, and regulations decided upon at a recent annual meeting of the board of directors have also been sent to firms who were not exhibitors in 1938, but who have requested information.

Many requests for additional space by former exhibitors have already been made and about 50 firms never exhibiting before have asked to be placed on the waiting list.

All space not contracted for by the deadline date of August 15 will be available to new firms or to former exhibitors desiring more facilities.

J. H. Wilson in Charge New Independent Exploration Office



JOHN H. WILSON

John H. Wilson, vice-president of the Independent Exploration Company, is in charge of the recently opened branch office of his company at 2015 Fort Worth National Bank Building, Fort Worth, Texas. Wilson is acting as district representative and staff geologist. Associated with him is R. A. LeMay, who will continue to manage the company's Tulsa, Oklahoma, office.

The **BEST BUY** *and* **WHY**

For REAL money saving in well pumping it is difficult to equal the

B-M-W ADMORE

Insert Pump Anchor

It ELIMINATES Working Barrels, Seating Nipples, Mechanical Shoes, and the Pulling of Tubing.

It SAVES on sucker rods and other equipment where high fluid level permits well to be pumped above bottom.

It COSTS LITTLE compared with the savings effected.

This B-M-W Anchor seats the Admore Liner Barrel or other Insert Pumps at any desired point in the tubing. It packs off and holds down directly in the tubing itself. Simply LIFT and TURN the rods when the desired setting position is reached, and the B-M-W ADMORE Insert Pump Anchor is "SET."

It screws directly onto the pump, replacing the conventional cup or mechanical hold-down. The Pump runs in usual way, with no special care required.

Complete data on request. See our advertisement in the "Composite Catalog"

THE BEST SUPPLY STORES

sell these Insert Pump Anchors, as well as other B-M-W Products: ● TEX TYPE Plunger Fittings and Valves ● NEILSON Tools (Safety Sucker Rod Hooks, Tubing Hooks, Rod Elevators, Sucker Rod Sockets, etc.) ● BALLS and SEATS (made for every pumping service) including the TOWER TYPE Ball and Seat and the 2-WAY NON-MAGNETIC Crown ● ADMORE Liner Barrels ● COLLINS Belt Clamps ● FLUID-LIFTER Pumps ● NU-TEX Pumps and Valves.

BRADFORD MOTOR WORKS INC.

OIL WELL SUPPLIES

BRADFORD, PA. — TULSA, OKLA.

You Wouldn't Pour Mud Into Engine Bearings

Think what would happen if you used rotary mud instead of lubricating oil in your motor. Your motor wouldn't last long. Yet, in your drilling well, with *unprotected* drill pipe, this very thing happens. The pipe rubs and grinds against the casing. But there's a way to prevent this. Install Patterson-Ballagh Drill Pipe and Casing Protectors.

Paradoxically, rotary mud is converted into an excellent lubricant when in contact with rubber. Auto wheels spin in mud. That's what occurs in a well when the string of pipe is equipped with Patterson-Ballagh Protectors. Least friction; no metal-to-metal contact.

PATTERSON-BALLAGH PROTECTORS

PATTERSON-BALLAGH CORPORATION

Plant and General Offices:
1900 E. 65th St., Los Angeles

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For
OIL *and* **GAS**

under High Pressure

You can handle pressures up to two thousand pounds under perfect control and pass on to your distributing lines whatever reduced pressure may be called for by use of the proper C-F Regulators. There are standard regulators for all pressures up to 600 pounds — for higher pressures designs are adapted to suit specifications.

The **CHAPLIN-FULTON MFG. CO.**

28-40 PENN AVE. CF PITTSBURGH, PA.

SO MUCH COMFORT
SO LITTLE COST

★ ★ ★ ★ ★

FROM $2 SINGLE

HOTEL HENRY

The Henry gives you accommodations and facilities to meet your hotel requirements completely – yet at a price no greater than for ORDINARY accommodations elsewhere... Perfectly located. Surrounded by department stores – banks – office buildings.

VISIT THE **SILVER GRILL**
NEW, BEAUTIFUL RESTAURANT

Be sure to see the novel
DOG HOUSE
IN THE
FORTUNE BAR

FIFTH AVENUE & SMITHFIELD

PITTSBURGH

Trade Literature

MERCO NORDSTROM VALVE COMPANY, subsidiary of the Pittsburgh Equitable Meter Company, 400 North Lexington Street, Pittsburgh, Pennsylvania, has issued Bulletin V-129 describing the company's Nordstrom Flexible Coupling Valves. The publication is available free upon request.

* * *

"LIFE HANGS BY A THREAD," is the title of a pamphlet issued by Macwhyte Company, Kenosha, Wisconsin, in which is described some of the interesting and important steps involved in the manufacture of wire rope. The booklet is being mailed to interested parties upon request.

* * *

A PICTURE AND WORD STORY of the use of Trinity Inferno cement in the oil industry is given in a pamphlet issued by the Trinity Portland Cement Company, Dallas, Texas.

* * *

GENERAL ELECTRIC COMPANY, Schenectady, New York, has recently issued two new bulletins. Bulletin GEA-137D describes the Type TS low-speed synchronous motor, and Bulletin GEA-1960A, Types ATB and ATI low-speed synchronous generators.

* * *

INTERNATIONAL HARVESTER COMPANY, Chicago, Illinois, has developed a simple industrial power cost record book that enables the tractor and power unit owner to obtain without much extra labor an accurate and comprehensive statistical picture of how his power equipment is operating and how much each tractor and each stationary engine is costing. For use with this book a printed form to be filled in daily by the tractor or engine operator has also been devised, and both these drivers' daily report forms and cost books are available free of charge to owners whether they operate International equipment or not.

* * *

. IN A 4-PAGE PAMPHLET, Diamond Chain and Manufacturing Company, Indianapolis, Indiana, clearly shows the progress of roller chain drives, from single to 16-strands, by series of application illustrations. The title of this pamphlet is "The Progress of Roller Chain Drives."

* * *

LINK-BELT COMPANY, Chicago, Illinois, announces the completion of its new 1278-page General Catalog No. 800, the largest and most comprehensive catalog it has ever issued, containing list prices, dimensions, weights, and engineering data on power transmission machinery, and on equipment for handling, screening, drying, cooling, and preparing materials mechanically. A 44-page pictorial section in the forepart of the book is devoted to giving a bird's-eye view of the many products the company makes.

* * *

REPUBLIC STEEL CORPORATION, Cleveland, has issued an attractive two-color, 44-page catalog entitled "Toncan Iron Pipe for Tough Service." This is the story of Toncan Copper Molybdenum Iron Pipe and covers such subjects as: the electric-weld process of manufacture; rust and corrosion resistance; recommended applications; details of various tests; physical properties; threading procedure; welding; sizes and weights; outstanding installations and service records in specific fields; how to specify and order; where to buy, and other information.

Requests for the catalog should be addressed to Republic Steel Corporation, Advertising Division, Cleveland, Ohio; ask for "Toncan Iron Pipe for Tough Service"—Adv. 333.

MEETINGS

Eastern U. S. Michigan Oil and Gas Exposition—August 1, 2, 3, 4, 5, and 6, Mt. Pleasant, Michigan.

California Natural Gasoline Association—August 3, Richfield Building, Los Angeles, California.

Appalachian Gas Measurement Short Course—August 21, 22, and 23, Morgantown, West Virginia.

American Society of Mechanical Engineers—September 4, 5, 6, 7, and 8, New York, New York.

American Chemical Society—September 9, 10, 11, 12, and 13, Detroit, Michigan.

National Petroleum Association, Annual Meeting—September 13, 14, and 15, Traymore Hotel, Atlantic City, New Jersey.

American Institute of Mining and Metallurgical Engineers, Petroleum Division—October 4, 5, and 6, Galveston, Texas.

Texas Mid-Continent Oil and Gas Association, Annual Meeting—October 5, 6, and 7, Houston, Texas.

American Gas Association, Annual Convention—October 9 and 10, New York, New York.

National Safety Congress and Exposition—October 16, 17, 18, 19, and 20, Chalfonte-Haddon Hall, Atlantic City, New Jersey.

Independent Petroleum Association of America, Tenth Annual Meeting—October 18, 19, and 20, Fort Worth, Texas.

American Institute of Mining and Metallurgical Engineers, Petroleum Division—October 19 and 20, Los Angeles, California.

American Petroleum Institute, 20th Annual Meeting—November 13, 14, 15, 16, and 17, Stevens Hotel, Chicago, Illinois.

American Institute of Chemical Engineers—November 15, 16, and 17, Providence, Rhode Island.

American Society of Mechanical Engineers—December 4, 5, 6, and 7, Philadelphia, Pennsylvania.

American Association of Petroleum Geologists, Annual Meeting—April 10, 11, and 12, 1940, Stevens Hotel, Chicago, Illinois.

American Petroleum Institute, Eastern District, Division of Production—April 11 and 12, 1940, Columbus, Ohio.

International Petroleum Exposition—May 18, 19, 20, 21, 22, 23, 24, and 25, 1940, Tulsa, Oklahoma.

Third World Petroleum Congress—June 9, 10, 11, 12, 13, 14, and 15, 1940, Berlin, Germany.

M. E. LEEDS

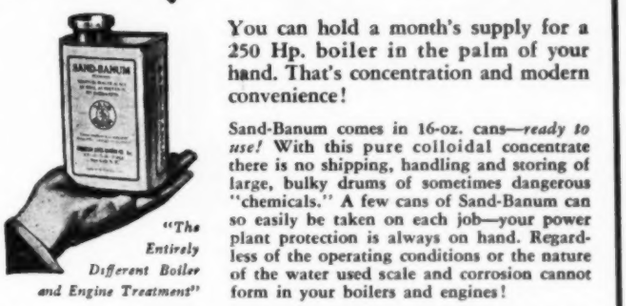
Leeds Becomes Board Chairman of Leeds and Northrup

Morris E. Leeds, founder and president of the Leeds and Northrup Company, is assuming the position of chairman of the board of directors, and Charles S. Redding, vice-president in charge of research and engineering, becomes president in an expansion of the company's executive set-up effective July 10. Chairman of the board is a post newly created to faciliate Leeds' participation in policy matters with which he will continue active.

This promotes to the presidency of the company one who has spent with it almost his entire business life.

C. S. REDDING

Gotkool
WATER CANS
& COOLERS
GOTT Water Cans are the practical way to keep drinking water cool for long periods, protected from impurities and always handy to the job. Snug fitting large removable top, strongly built to withstand rough usage. GOTT Water Coolers have extra large covers and a handy non-leaking push button faucet. Your Supply Store has them, get one today! . . . . .
GOTT WATER CAN
Made in 1½, 3, 5, and 10 gallon sizes.
GOTT WATER COOLER
H. P. GOTT MFG. CO.
WINFIELD, KANSAS
KEEP PURE DRINKING WATER ALWAYS HANDY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SAND-BANUM
"The Entirely Different Boiler and Engine Treatment"
You can hold a month's supply for a 250 Hp. boiler in the palm of your hand. That's concentration and modern convenience!
Sand-Banum comes in 16-oz. cans—ready to use! With this pure colloidal concentrate there is no shipping, handling and storing of large, bulky drums of sometimes dangerous "chemicals." A few cans of Sand-Banum can so easily be taken on each job—your power plant protection is always on hand. Regardless of the operating conditions or the nature of the water used scale and corrosion cannot form in your boilers and engines!
Don't Buy It—PROVE IT FIRST! Try Sand-Banum for 30, 60 or 90 days in your own equipment. Then if you are not entirely satisfied with results—you pay us nothing! Arrange for a test today and know the "Safe Way to Save!"
AMERICAN SAND-BANUM COMPANY, Inc.
9 Rockefeller Plaza
New York City

Look for the Arm-and-Hammer
ARMSTRONG BROS.
Improved PIPE WRENCHES
Just grip this wrench and you will feel the difference. It seems a part of you. Takes a positive hold without wobble or rattle. 10 major design improvements; no clumsy "frame." Nut can't fall out. Heavy forged-in lugs to take up side strain. Coil spring. Handle heaviest at point of strain. Replaceable tool steel jaws. Self-cleaning (ball and socket) action. No projection below line of handle. All steel.
"The Tool Holder People"
ARMSTRONG BROS TOOL CO
331 North Francisco Ave., Chicago, U. S. A.
Eastern Warehouse & Sales: 199 Lafayette St., New York, New York
Write for circular.

NEW!

Improved Features of O'Bannon Nu-Standard Pump Assure Longer Service and Afford Larger Fluid Capacity

- All joints are shouldered straight threads. Straight threads are leak proof, lock against accidental unscrewing, can be used over and over, and keep connected parts always in alignment.
- Fluid capacity is greater. Opening through inner tube and plunger is larger. The bore of the 2½" and 3" pumps has been increased over the old Standard Pump.
- The Nu-Standard Pump conforms to A.P.I. dimensional standards. This affords complete interchangeability.
- Supplied in three sizes: 2"x1½", 2½"x2", 3"x2½"; six lengths: 5, 6, 7, 8, 10, and 12 feet; and with four different plungers: Regular Repack, Eight Cup, Combination, and Discpak.
- Gives increased service and fewer rod jobs when equipped with a Cro-Lay barrel—especially in sand or corrosive conditions.

Sold by

SUPPLY STORES

Manufactured by

WALTER O'BANNON COMPANY

Tulsa Fort Worth

In the Illustration

The O'Bannon Nu-Standard Pump with Regular Plunger and plunger standing valve. See pages 16-20 in the O'Bannon Catalog No. 9 for complete description.

O'BANNON

NU-STANDARD PUMPS

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